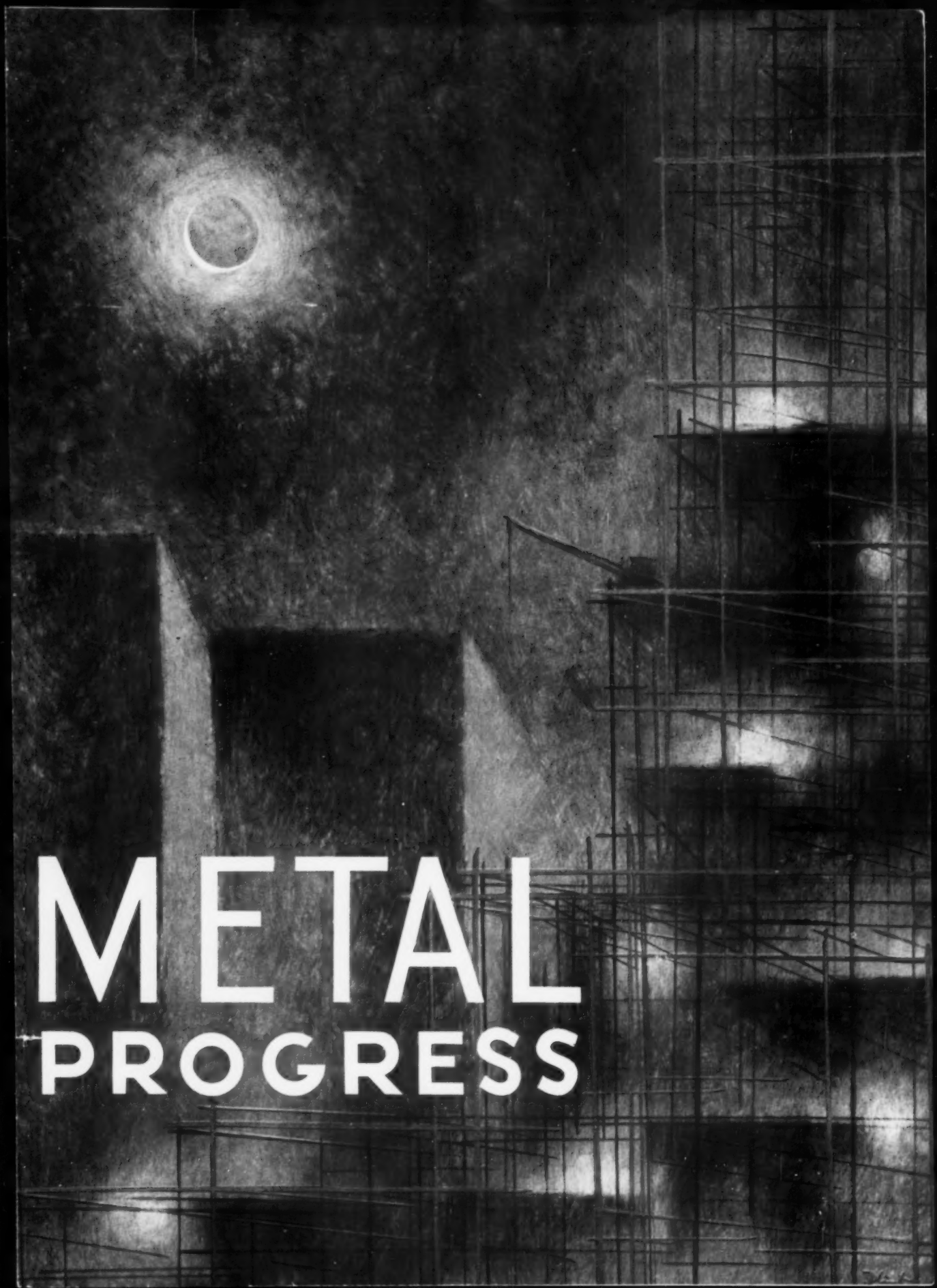

METAL
PROGRESS

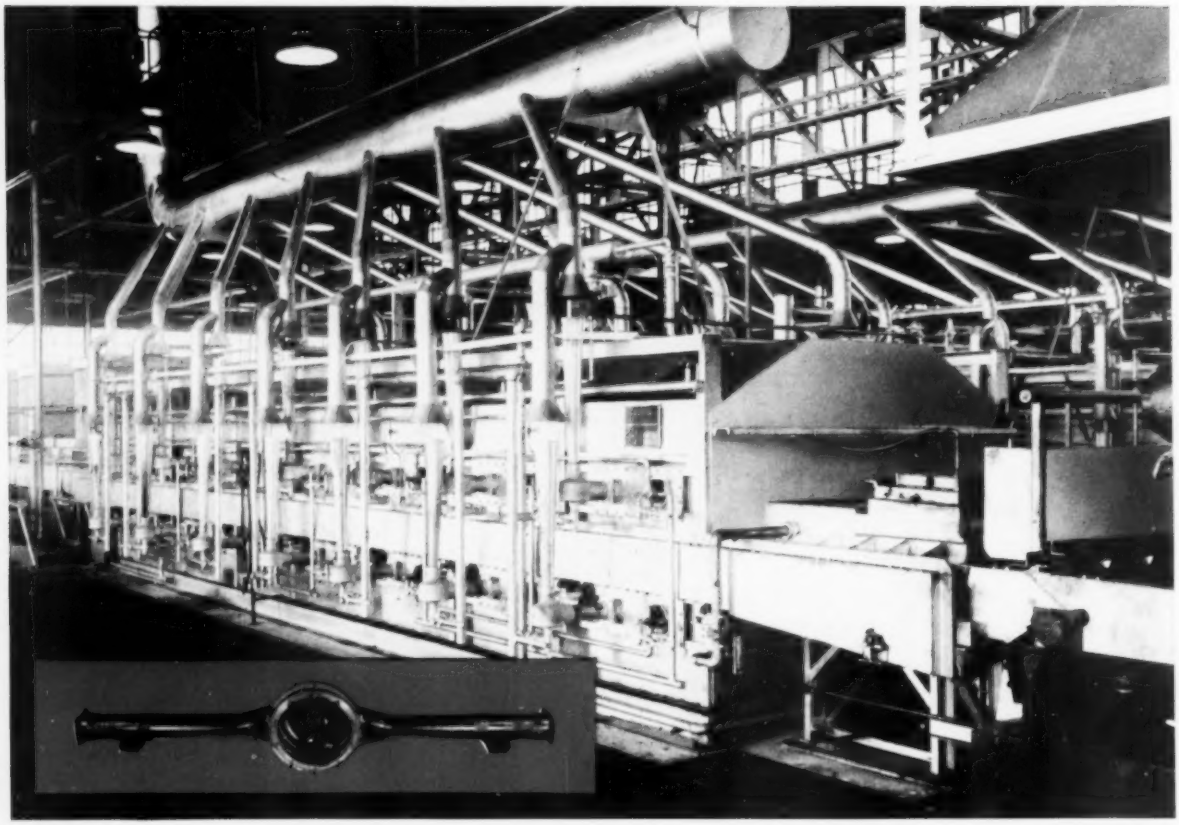
at five tons per hour

Ford Motor Company makes rear axle housings from welded steel tubing. Deformation in forming operations is so severe that the tubing must be clean annealed.

Two 'Surface' Roller Hearth Continuous Furnaces do the job for Ford at a rate of five tons of tubing per hour, per furnace. Radiant tube heating plus a 'Surface' controlled atmosphere (DX gas) prevents oxidation, eliminates the necessity of a pickling operation.

Shown below is the charge end of one of the 'Surface' Roller Hearth Continuous Furnaces. They are key components in this highly integrated production line that automatically cuts, forms, welds and anneals, rear axle housing tubes from coiled strip stock.

roller hearth furnace anneals steel tubing to take "the bends"



In more than a quarter century of use, 'Surface' Roller Hearths have demonstrated remarkable versatility in heat treatments on tubing, bars, coils, discs, sheets, both ferrous and non-ferrous—carbon restoration, heating for forming, annealing, high-speed stress relieving, hardening and drawing. They use direct firing, convection heating, or radiant tube indirect heating, all incorporating gas-saving, automatic proportioning burner equipment. Take advantage of 'Surface' experience and versatility to boost your production and profits.

Write for 'Surface' Literature Group H-53-3.

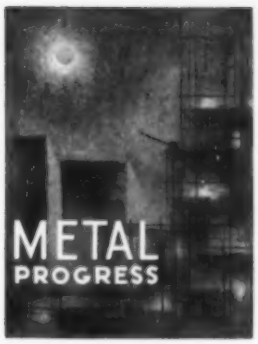
Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

IN THIS ISSUE



The Cover's Spidery Skyscraper Was Designed and Painted by Leroy Flint, Curator of Education, Akron Art Museum. Mr. Flint also teaches modern art classes at Cleveland Art Museum

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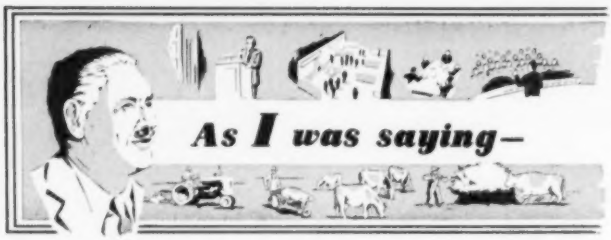
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• **See** *Bill's Column on the other side*



IT WAS A PLEASANT EXPERIENCE to attend the annual meeting of the British Iron & Steel Institute and the Institute of Metals when in London earlier in the summer. It was so similar to the ⊜ meeting when the clan gathers and there's the "hello" and greetings of fellow members. The President's address and business meeting occupy the first session, with a break for coffee at 11:30 for 15 min. and then a resumption of the program. (That break for coffee made a fine impression on me and it may be a good idea to try it at the Cleveland convention; it might increase attendance, for who wouldn't sit through two papers and discussions to have a demi-tasse of Statler's best brew?) A buffet luncheon is served in the Institute headquarters where the meetings are held and the members do a good job in attending all the sessions.

The highlight of the meeting was the annual dinner. Over 1200 members attended, all in evening dress (white tie and tails) and wearing decorations. The tables seated ten, while the head table (called "top table") extended the full length of the banquet hall and seated 60. I was invited to the President's reception in a large adjoining room with the officers, past and present, the medalists, those who were to respond to toasts (the speakers), steel company officials, Government officials and guests. At the reception I learned for the first time that as representative of the ⊜ I was to sit at the top table with the top brass. I was pleased at this recognition of your Society and scanned with some degree of eagerness the seating arrangements. I found after my name the letters AL, which meant top table left of center. Then on the seating order of the top table I discovered that I was seated just three chairs from the center place occupied by the new president of the Institute, the intervening places being occupied by the speakers appearing on the printed program. If placing at the speakers' table has any significance at all, then all of us may take just pride in the recognition accorded the ⊜.

The gaily uniformed toastmaster (a hired personage) made the announcements and introductions. The talks were interesting and humorous, and made for fine listening. It remained, however, for Sir Andrew McCance, a Bessemer medalist, a past officer of the Institute, and a 30-year ASMer, who responded to the toast "To our Guests", to cap the climax of an evening of surprises (at least to me) when he entered into an extended flow of complimentary and laudatory statements about your Secretary and the accomplishments of your Society. Measured by the applause that followed, one could realize that the knowledge of the work and deeds of your Society had spread far and wide and had been recognized.

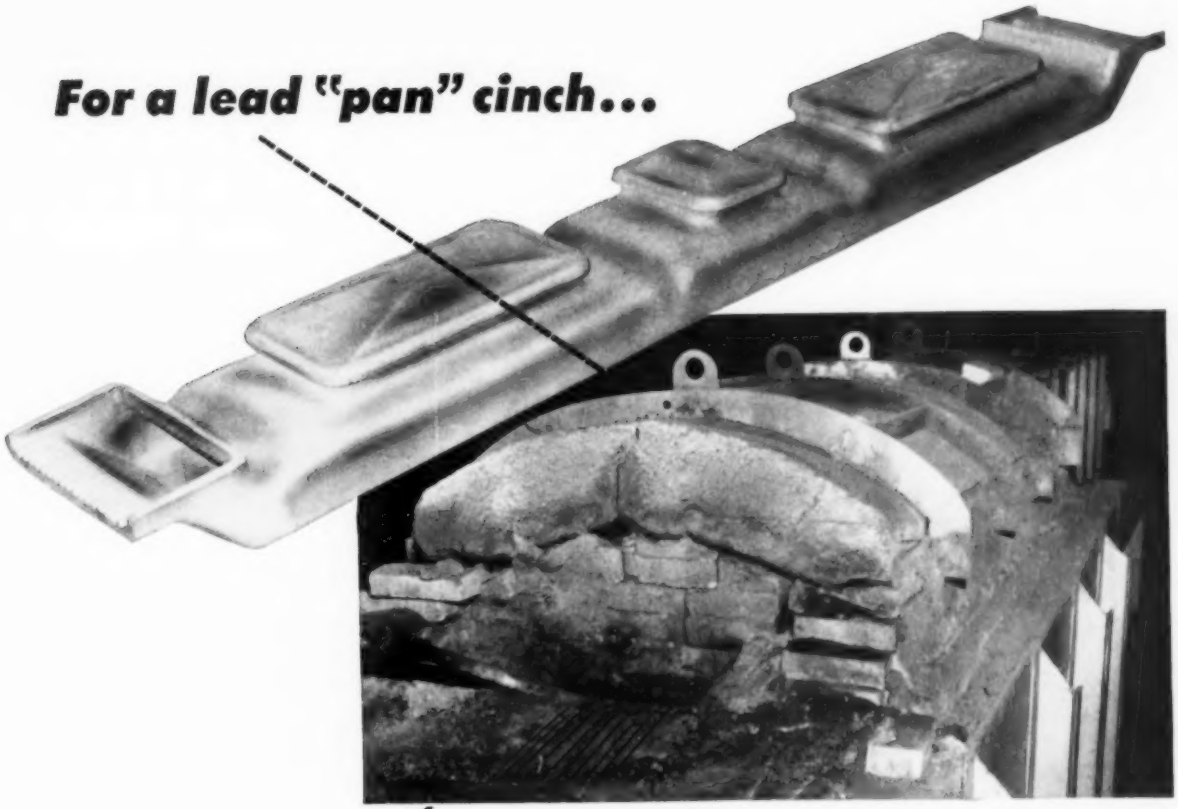
I know the reception at this banquet must mean a lot to you as it does to me. Especially to the older members who worked and strove through the years to do a progressive job as technical societies go, and to the thousands of ASMers who have contributed papers, worked on committees, served as Chapter and National Officers, and to the membership at large, the recognition from a great sister society, like a pat on the back, will spur us on to greater endeavor and higher achievements.

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

For a lead "pan" cinch...



it's THERMALLOY* to outlast cast iron by 479 days!

A large steel and wire company uses a double-lead patenting furnace to give good drawing qualities to wire. In this process, wire is drawn through a "lead" pan enclosed in the furnace where temperatures range from 1600 to 1650°F.

Previously, cast iron "lead" pans were used . . . and the furnace had to shut down nearly every 21 days because the pan burned out and needed replacement. Then, a Thermalloy "lead" pan with integrally cast sinkers was installed. *To date, this pan has over 500 days of service* . . . saving this company expensive hours of repair and down time.

This is just one example of how a Thermalloy heat-resistant casting has helped a manufacturer to realize more economy in heat-treating parts. Do you have a similar need for Thermalloy in retorts, furnace parts, trays, racks, pots or muffles? Call in an Electro-Alloys engineer for full information, or write Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

THERMALLOY "LEAD" PAN ADVANTAGES

- Resists air-line attack, scaling and oxidation.
- Higher strength prevents sagging and distortion.
- Less weight means easier installation and less maintenance of supporting arches.
- Greater resistance to abrasion.

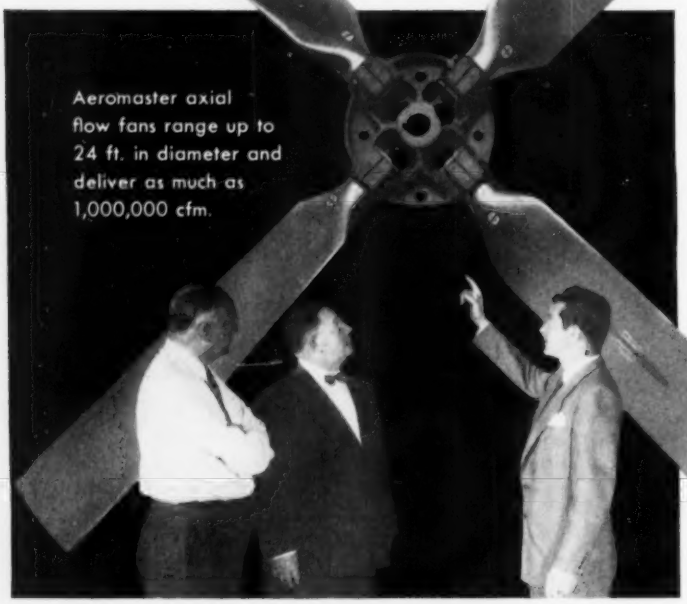
*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

DUCTALLOY® CASTINGS GIVE KOPPERS FANS

Strong, Sound Hubs



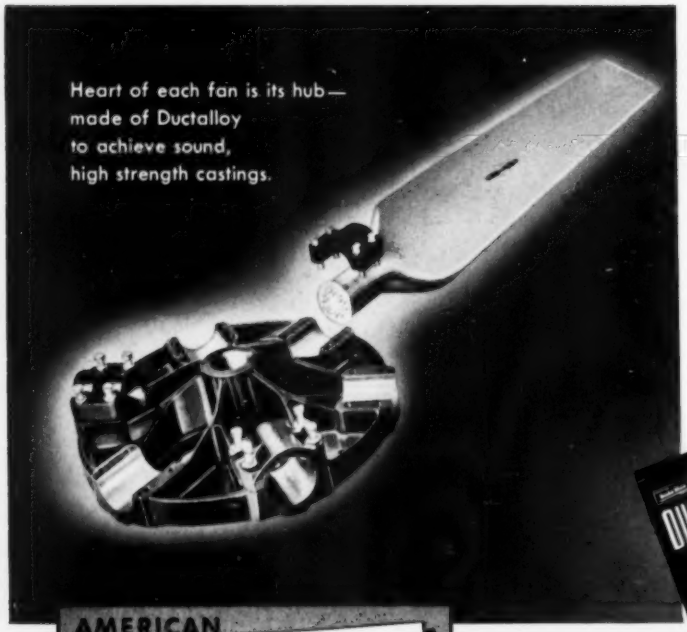
Aeromaster axial flow fans range up to 24 ft. in diameter and deliver as much as 1,000,000 cfm.

EASILY CAST, EASILY MACHINED

High performance fans made by the Aeromaster Fan Department of Koppers Company, used in cooling towers near diesel engines and compressors, must withstand considerable applied vibration in addition to normal operating loads. For this reason cast steel was originally specified to provide the necessary hub strength; but machining costs were excessive, surfaces were poor, and too many castings were "lost" when machining revealed hidden defects. A switch to malleable iron only aggravated the problem of casting soundness. The answer was Ductalloy 60—Brake Shoe's easily machined high strength ductile cast iron.

MACHINE SHOP REJECTS ENDED

Ductalloy 60 is a ferritic iron having 60,000 psi minimum tensile strength, 40,000 psi minimum yield strength and 10% minimum total elongation, all guaranteed. Use of this material has virtually eliminated the high scrap loss formerly encountered when defects were uncovered during machining of castings made in either steel or malleable iron.



Heart of each fan is its hub—made of Ductalloy to achieve sound, high strength castings.

your problem — Ductalloy may solve your problem if it involves economical production of complex metal shapes that are difficult to cast in steel, expensive to forge or lacking strength in gray iron. Brake Shoe's experience, research laboratory and experimental foundry are available to help you best utilize Ductalloy's unusual combination of characteristics. Write for this new technical bulletin today.



DUCTALLOY castings are made by:
BRAKE SHOE & CASTINGS DIVISION
ENGINEERED CASTINGS DIVISION

AMERICAN **Brake Shoe** COMPANY

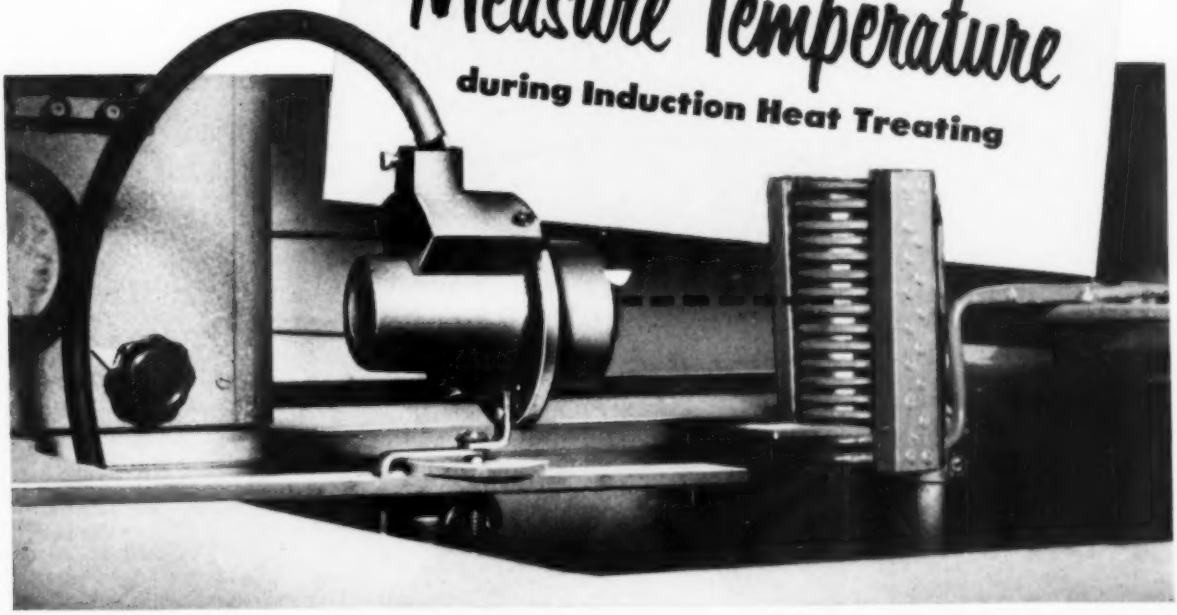
230 PARK AVENUE
NEW YORK 17 • NEW YORK

To Speedomax Recorder or Controller

Now you can

Measure Temperature

during Induction Heat Treating



In this simplified set-up the Rayotube detector is sighting on steel bar stock between coils of the heating unit. A Speedomax controller connected to the Rayotube automatically regulates and records temperature.

This installation is at Lehigh University where the Dept. of Metallurgy uses a Lepel High Frequency Induction Furnace to investigate the influence of induction heating on the properties of various steels.

With this new Rayotube detector, it is possible for the first time to measure and control temperature of metal parts being heat treated by high frequency induction during their entire cycle.

Mounted only four inches from the induction heating coil, this newest member of the Rayotube family can focus on an opening as small as 0.1 inch between turns of the coil, and through this opening sight on the hot surface of the work. The Rayotube is so fast it reaches 99% of true temperature in 0.6 second . . . is always within 0.15 second of changes in work temperature.

Teamed with a Speedomax instrument it enables you to automatically measure, record and—if desired—control the entire heating cycle directly from the temperature of the work.

If you'd like more details about using Rayotube detectors on high frequency induction heating or similar applications, just write us at 4927 Stenton Avenue, Philadelphia 44, Pa.

SPECIFICATIONS FOR THE SMALL TARGET RAYOTUBE DETECTOR

Catalog Number	8891-C
Response Time	0.15 second to 63% of temperature change; 0.6 second to 99% of temperature change.
Minimum Target Size	0.1 inch at 4 inch focus
Range	1100 F up
Housing Temperature	Can safely withstand 350 F maximum ambient temperature
Optical System	Narrow-angle, double mirror type with visual viewer
Case	Metal, hermetically sealed, including covered leadwire terminal block

LEEDS & NORTHRUP

instruments — *automatic controls • furnaces*

Ind Ad NS4(3)

Metal Progress is published and copyrighted, 1953, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

Fill your metal melting



with Norton SPECIAL Refractories

You keep production going longer and shutdowns are fewer when you use Special Norton Refractories prescribed and engineered to your exact requirements.

There is no one refractory that will serve all purposes. But Norton Rx Service will help you find the one best suited to your purpose.

Norton makes Refractories to *combine* the very characteristics you need for your particular metal melting and processing. From four entirely different and carefully developed basic materials you get the correct Rx . . . such properties as resistance to extreme heat, thermal shock, abrasion and chemical reactions; good thermal conductivity; insulation and various special electrical qualities.

The Norton "Basic 4" for your Rx

ALUNDUM* (fused alumina) is an electric furnace product made from bauxite. It is alumina in its most dense and unshrinkable form. Alundum is a chemically inert material of high refractoriness, electrical resistivity, thermal conductivity and it is chemically stable.

CRYSTOLON* (silicon carbide) is an excellent heat conductor and is highly resistant to spalling and to slag adherence and penetration.

MAGNORITE* (fused magnesia) is one of the most refractory oxides available commercially. It is resistant to basic slags and is used principally for lining induction furnaces in which refractory

metals and alloys of both ferrous and non-ferrous types are melted.

FUSED STABILIZED ZIRCONIA is a Norton "first" in research. No other refractory offers such an unusual combination of properties. It has both amazing resistance to high temperature (up to 4700°F) and extremely low thermal conductivity. It is chemically inert in contact with ferrous alloys.

Some R Examples for different needs

For high frequency induction furnaces to melt more steel per lining, it's Norton MAGNORITE cements for melts ranging from straight steel to heat-resistant combinations. Made specifically to be dry-rammed. MAGNORITE crucibles in various compositions available for smaller furnaces.

For indirect arc furnaces, foundries get fine results with ALUNDUM or MAGNORITE crocks, covers, and cements of the right specification.

For low-frequency furnaces, choose ALUNDUM or MAGNORITE, depending on the metals or alloys you are melting such as cupro-nickel and nickel-silver, high copper alloys and Al, Te, and Si bronzes. Both have the high-rammed density that resists metal penetration, erosion and chemical attack.

In back-slagging cupolas, CRYSTOLON slag hole blocks resist slag action 5 to 15 times longer than fire clay . . . show little or no signs of softening, spalling or cracking at temperatures as high as 3050°F.

In heat-treating and sintering furnaces, there are ALUNDUM and CRYSTOLON hearth plates, pier brick, muffles, muffle plates, skid rails, recuperator tubes, burner tunnel and embedding cements in various compositions.

Make Norton Your Working Partner in finding the right answer to your own working problems. To those we apply the accumulated research and skills of over 40 years' experience. Norton engineers are also prepared to work with or give information to your engineering staff. Write NORTON COMPANY, 327 New Bond St., Worcester 6, Mass. Canadian Representative, A. P. Green Fire Brick Co., Ltd., Toronto.

NORTON

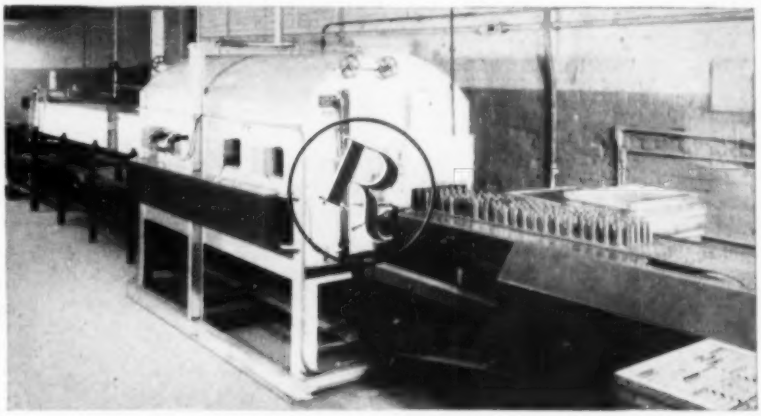
Special REFRACTORIES

Making better products to make other products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries



Norton CRYSTOLON slag hole block. Picture shows one of many similar installations in foundries. Users have reported up to 65 hours operation without shutdown.

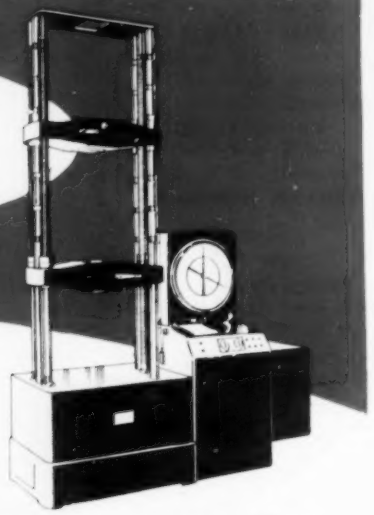


Norton CRYSTOLON hearth tile in this electric furnace is an ideal refractory bed for the conveyor belt. It has an unusually long life.



Norton MAGNORITE cement. 1000-lb. high frequency induction furnace after metal has been poured. Note how MAGNORITE cement lining resists mechanical and chemical attack.

FROM ORANGE CRATES TO ARMOR PLATES



you can test practically anything with a

RIEHLE

UNIVERSAL TESTING MACHINE

Owning a Riehle Pendomatic is like having five testing machines in one. Why? Because every Riehle Universal Testing Machine has 5 scale ranges to permit closer and more accurate reading. You can test specimens with relatively low rupture points and specimens with high yield points — all on the same machine. All you do is turn the selector knob to the logical range and run your test. Guaranteed accuracy is within ½ of 1%. Only a Riehle Pendomatic gives you 5 scale ranges.

WHAT ARE YOUR SPECIFIC NEEDS?

Riehle builds Universal Testing Machines with either hydraulic loading unit or screw power loading unit, in standard sizes up through 400,000 lbs. capacity and larger when required. Talk over your specific requirements with a Riehle specialist — you'll find him listed in the phone book under "testing equipment" — or write for illustrated catalogs.





Test in progress on Riehle 120,000 lb. Screw Power machine. Photo courtesy of Armour Research Foundation.

RIEHLE TESTING MACHINES

Division of AMERICAN MACHINE AND METALS, INC.

EAST MOLINE, ILLINOIS

Chicago • Cleveland • Denver • Houston • Los Angeles
New York • Pittsburgh • Pittsfield, Mass. • Seattle

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

Titanium Melting Process

Mallory-Sharon Titanium Corp. has announced the development of a new melting process for titanium. Neither arc nor induction melting has been entirely satisfactory. The new process, known as Method "S", combines the best features of the two older methods and results in the following advantages: *(a)* Ingots are homogeneous and display the same characteristics throughout, *(b)* carbon content



can be controlled to any amount specified and held as low as the amount inherent in the sponge material (a titanium electrode is used in place of a carbon electrode, and the melting is accomplished in a water-cooled copper crucible), and *(c)* the yield is increased markedly, and more metallic titanium can be produced from a given amount of sponge raw material since scrap loss is reduced.

For further information circle No. 325 on literature request card on p. 32-B.

Air-Gas Proportioner

The North American Series 630 proportioner is a relay-controlled air-operated cross-connected governor designed to meet the need in steel mills and elsewhere for an inexpensive device to proportion accurately large quantities of low-pressure gas and air used for combustion. The proportioner may be installed in either a gas or an air line of any standard pipe size ranging from 4 through 16 in. It consists of a nondirectional butterfly valve operated by an air motor and controlled by a relay that receives pressure impulses from both the gas and air lines. The proportioner may be mounted in either a

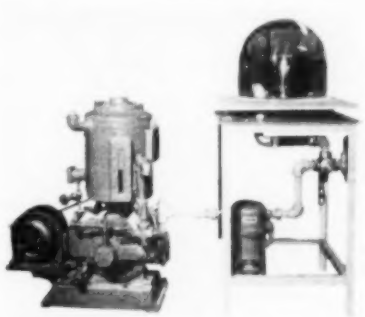


horizontal or vertical run of pipe. Capacities at a pressure drop of only 1 oz. per sq.in. range from 24,100 cfh. of air for the smallest size to 385,000 cfh. for the largest.

For further information circle No. 326 on literature request card on p. 32-B.

Precision Casting

Vacuuming units for industrial precision investment casting are now being made to order by Alexander Saunders & Co. Vacuum is needed to remove air from investment mix immediately after the material has been



made into a slurry and is also needed to remove air from molds after the slurry has been poured over the wax patterns. Unit consists of a vacuum pump, filter, three-way air valve, steel table with jiggle plate, rubber mat.

For further information circle No. 327 on literature request card on p. 32-B.

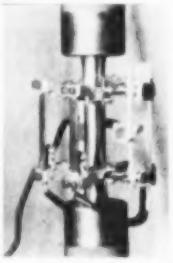
Chemical Steel Polish

MacDermid, Inc., has announced the development of MirroFe, a room temperature chemical steel polish. This new process produces a brilliant luster on most steel articles by simple chemical immersion. It also reduces surface roughness and deburrs sharp edges. A 1-min. immersion produces a luster equivalent to that obtained by a 20-min. deposit of bright nickel. The new product also has application in chemically polishing steel dies to give a fine micro finish which reduces die wear, thereby increasing die life.

For further information circle No. 328 on literature request card on p. 32-B.

SR-4 Extensometer

The first SR-4 type electrical extensometer to be constructed commercially has been announced by Baldwin-Lima-Hamilton Corp. Although still experimental in user applications, extensometers and deflectometers incorporating SR-4 strain gages as sensing elements are available for meeting varying requirements. The new extensometer is for use in tensile strength tests of standard 0.505-in. diameter test specimens with 2-in. gage length. The one illustrated has a measuring range of 0.2 in. when used with an SR-4 recorder, also newly developed for producing stress-strain curves in rectangular coordinates. Other measuring ranges are available. Four strain magnification ratios, 50, 100, 250 and 500:1 are obtainable with this instrument.



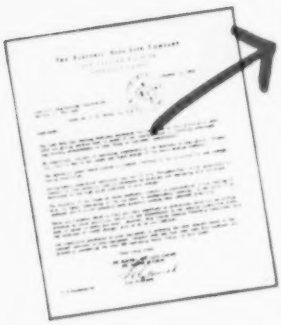
For further information circle No. 329 on literature request card on p. 32-B.

Screw-Machine Oils

Four new nonemulsifying cutting oils have been announced by Sun Oil Co. Sunicut 11-S and 209-S are nonstaining, dual-purpose oils developed primarily for medium-duty and heavy-duty operations on automatic screw machines. Sunicut 102-S and

DIE CASTERS

Here's an *important* message for you from THE ELECTRIC AUTO-LITE COMPANY read it for yourself...



Gentlemen:

The Lake Erie Die Casting Machines purchased for operation at this division of AUTO-LITE are giving service that is proof of the incorporation of carefully developed engineering advancements in this field of equipment manufacture.

By comparison, failure of operating components of the machines is negligible. Primarily, this is due to the sound and rigid design of the basic machine members.

The hydraulic panel board system is compact, valving is easily accessible and leakage easily controlled.

Radiographic inspection indicates that use of your "Pressure-Pac" in the construction, results in less porosity than is evidenced by machines not employing this principle, developed to the high point achieved in your design.

The rigidity of your frame of these machines, results in acceleration of the setting of dies, as equal tensioning of the tie bars is accomplished, usually, in one cycle of adjustment which is not possible upon machines lacking this inherent stability.

These are features which we feel are very important as production rates are materially affected by these qualities, which are not discernible in the usually simplified statement of speed in shots per hour...

Our repetitive purchases of your equipment is probably the most sincere proof of our current interest in your equipment, coupled with the fact that Lake Erie machines are presently accounting for over 300 operating hours, daily in this plant.

F. H. Drummond
Vice-President

Carefully developed Engineering advancements

Sound, rigid design

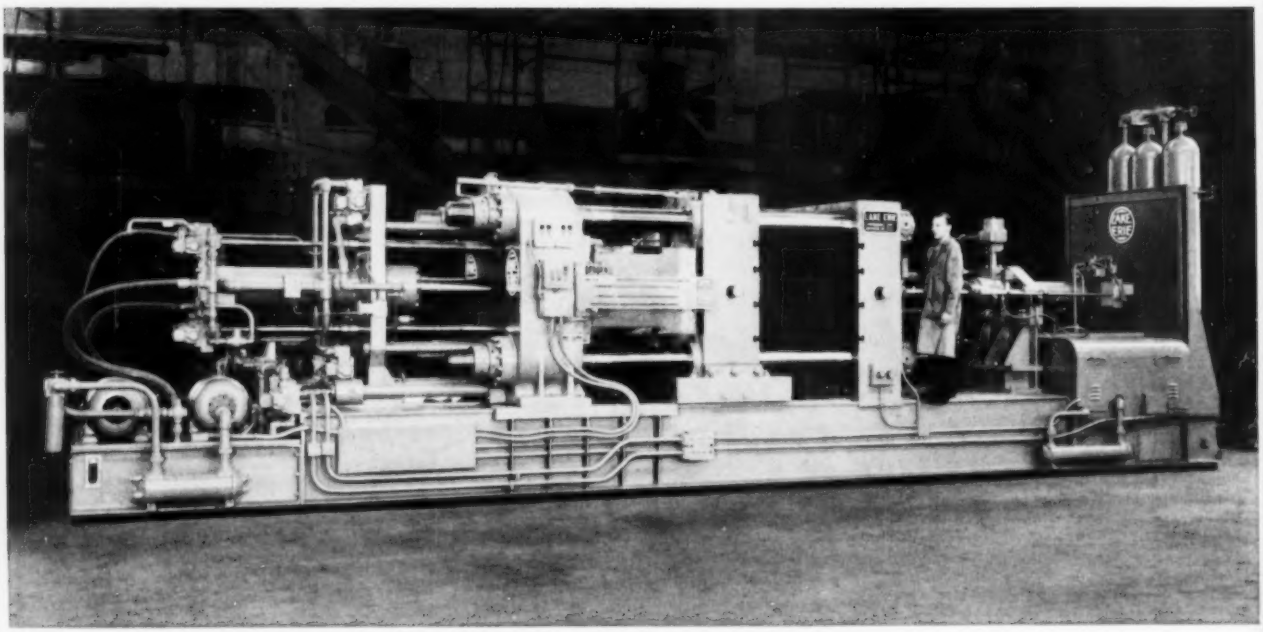
Less porosity with "Pressure-Pac"

Dies set in one cycle

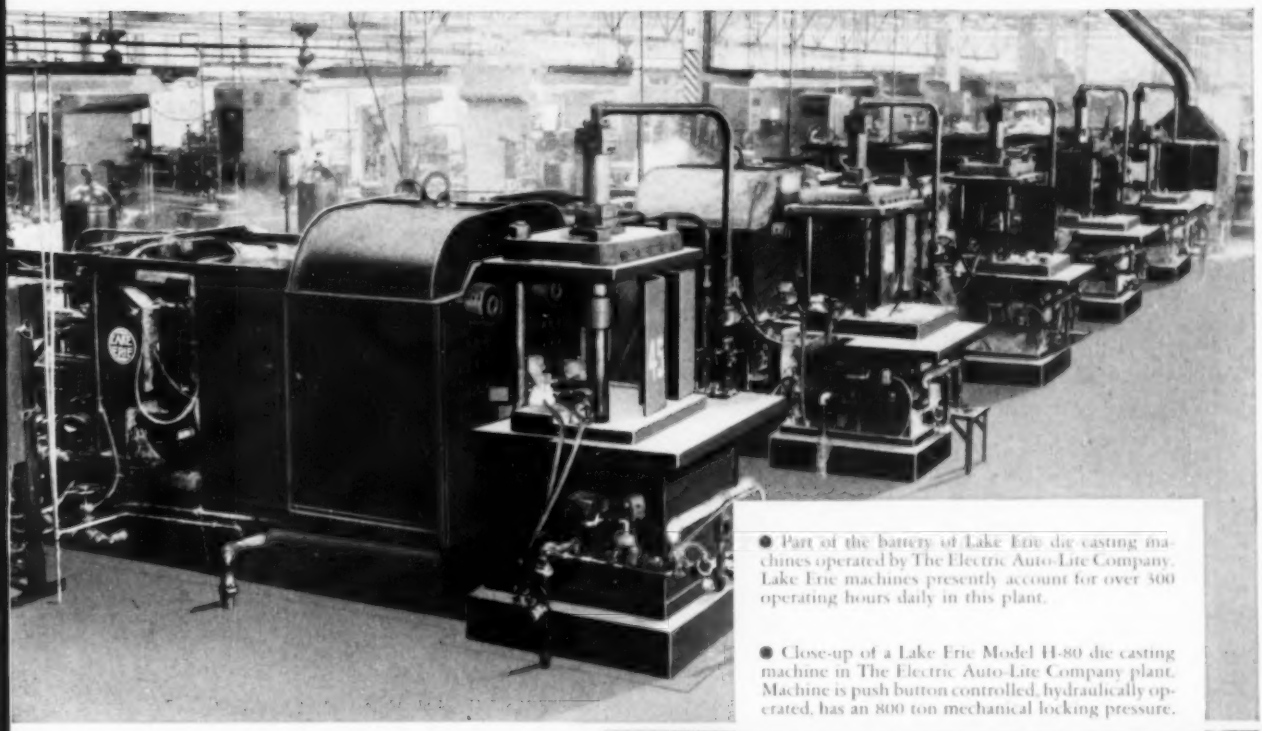
Production rates materially affected

REPETITIVE PURCHASES PROOF OF EQUIPMENT

...evidence that Lake Erie machines can improve your die casting operations



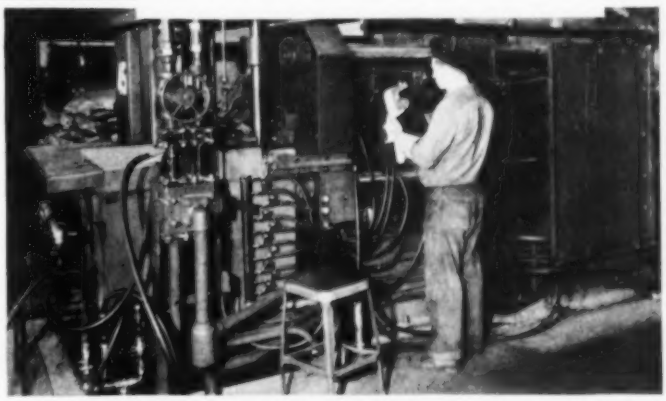
●Lake Erie Die Casting Machines are available in 10 models, ranging in capacity from 100 to 1000 tons for casting all the usual non-ferrous metals and alloys. Illustrated is new 1000 ton model.



● Part of the battery of Lake Erie die casting machines operated by The Electric Auto-Lite Company. Lake Erie machines presently account for over 500 operating hours daily in this plant.

● Close-up of a Lake Erie Model H-80 die casting machine in The Electric Auto-Lite Company plant. Machine is push button controlled, hydraulically operated, has an 800 ton mechanical locking pressure.

THE LAKE ERIE DIE CASTING MACHINES referred to by The Electric Auto-Lite Company have features long desired but never before available in die casting equipment. In addition to the patented "Wedge Cam Toggle" and "Pressure-Pac" injection unit, they have many other mechanical improvements that put this equipment strictly in a class by itself. These advantages are not restricted in use to The Electric Auto-Lite Company. Other Lake Erie customers are enjoying them and you can too. Write or call us today to discuss improved equipment for your plant.



Write for this Catalog

Illustrations, specifications, application data—all are here in complete detail with full explanation of the patented "Wedge Cam Toggle" and "Pressure-Pac" production advantages.



AMONG COMPANIES PURCHASING THIS EQUIPMENT SINCE ITS INTRODUCTION IN 1952

The Electric Auto-Lite Co.
Bendix Aviation Corp.
Bohn Aluminum & Brass Corp.
General Electric Co.
McCulloch Motors Corp.
Johnson Motors
The Dow Chemical Co.
Allis-Chalmers Mfg. Co.
Westinghouse Electric Corporation
Central Die Casting & Mfg. Co., Inc.

LAKE ERIE
ENGINEERING CORP.
BUFFALO, N.Y. U.S.A.

LAKE ERIE ENGINEERING CORP.

General Offices and Plant
620 Woodward Ave., Buffalo 17, N. Y.

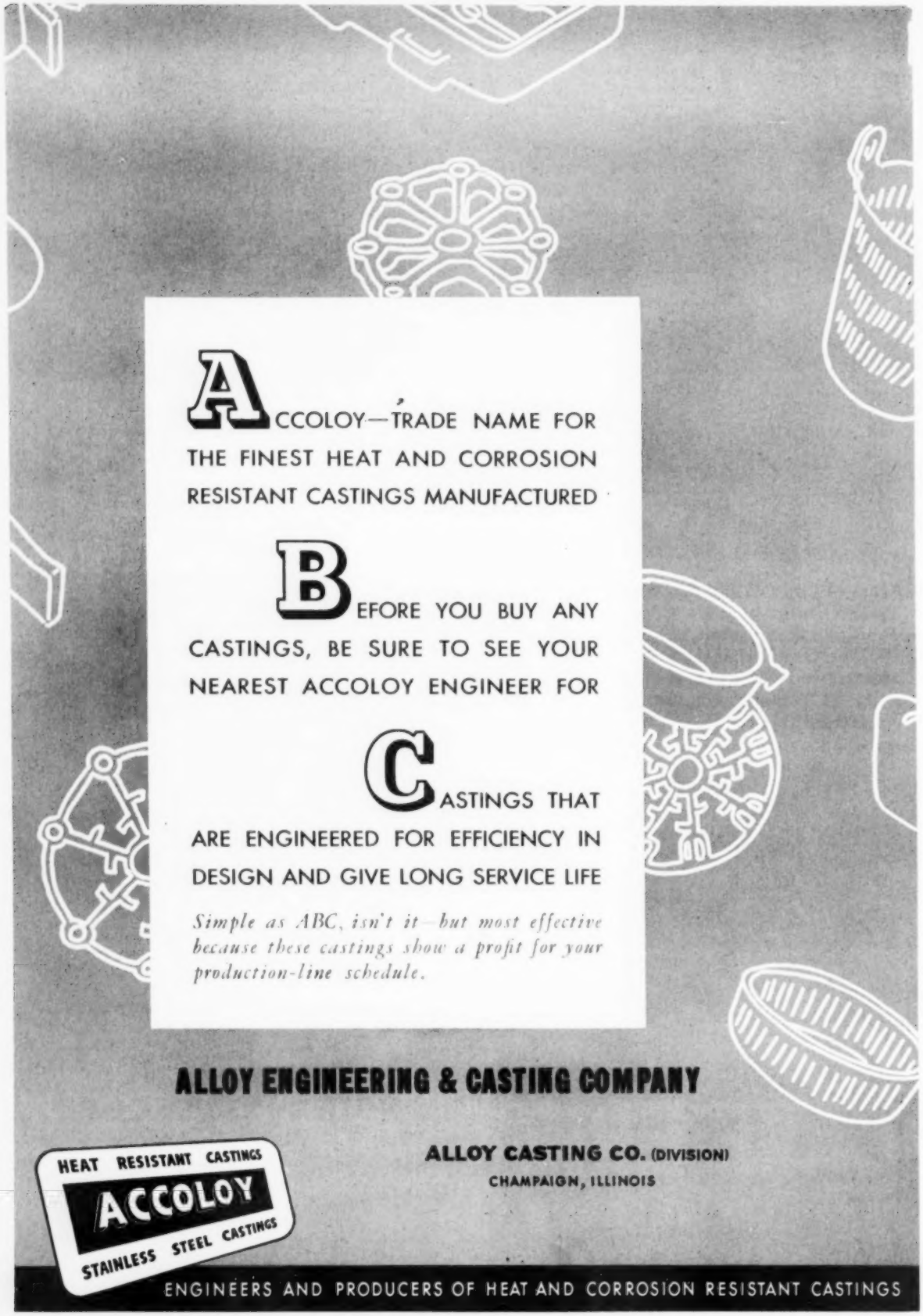
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Manufactured in Canada by: CANADA IRON FOUNDRIES LIMITED

HYDRAULIC PRESSES • DIE CASTING MACHINES
ROLLING MILL AUXILIARY EQUIPMENT

LAKE ERIE ®

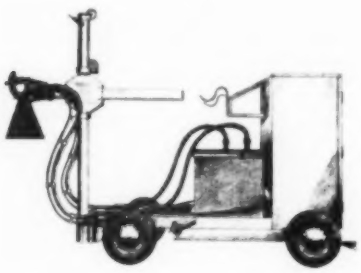

ACCOLOY—TRADE NAME FOR THE FINEST HEAT AND CORROSION RESISTANT CASTINGS MANUFACTURED
BEFORE YOU BUY ANY CASTINGS, BE SURE TO SEE YOUR NEAREST ACCOLOY ENGINEER FOR
CASTINGS THAT ARE ENGINEERED FOR EFFICIENCY IN DESIGN AND GIVE LONG SERVICE LIFE
Simple as ABC, isn't it—but most effective because these castings show a profit for your production-line schedule.
ALLOY ENGINEERING & CASTING COMPANY
HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS
ALLOY CASTING CO. (DIVISION)
CHAMPAIGN, ILLINOIS
ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

110-S both contain active-type sulphur and are especially effective for heavy-duty screw machine work and for other heavy-duty operations such as broaching, gear hobbing, threading and tapping. Improved performance of these oils is obtained by newly developed additives.

For further information circle No. 330 on literature request card on p. 32-B.

Mobile X-Ray Unit

An improved 250-kv. mobile X-ray unit for radiographing unwieldy objects that require positive X-ray inspection is available from the Westinghouse Electric Corp. Improvements in the new model are principally in flexibility and ease of handling. The operator has been given additional protection so that he can stand inside the cab. The radius of turn has been improved so that the

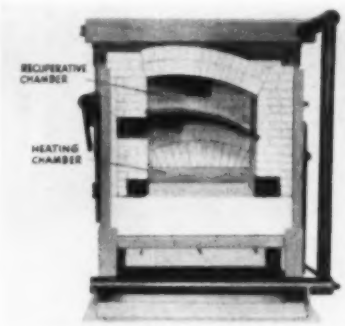


unit can be more easily positioned. The chassis has been strengthened and the center of gravity lowered. Wide inspection coverage is accomplished with a long vertical column and a horizontal tubearm. The minimum tube-head-to-floor distance is 36 in. and the maximum 108 in. Throughout this 72-in. vertical travel, the tubehead has a horizontal travel of 48 in. The vertical column can be rotated 360 deg.

For further information circle No. 331 on literature request card on p. 32-B.

Scale-Free Heating

The Lithium Co.'s new method of direct-fired heating makes it possible to obtain the necessary soaking periods at required temperatures to assure equalization of temperature of the work load. Another important feature of this kind of furnace protection is that it is possible to idle the furnace at control temperature with a full load for extended periods of time, such as might be necessitated by tool changes or press maintenance, without affecting the surface condition of the work upon final discharge. By heating primarily in a direct-fired unit, while simultaneously creating a furnace atmosphere with the heating gases, it is possible to obtain efficiency in not only radiant heating but also in heating by conduction and convection. When these hot atmos-



phere gases are then burned to completion in the recuperative section within the furnace chamber, virtually all of the heat is released to the work, thus giving an important factor in fuel savings.

For further information circle No. 332 on literature request card on p. 32-B.

Beryllium Copper Strip

Beryllium copper alloy strip, precision-rolled to very close tolerances and to thin gage and foil, is now available from American Silver Co. Beryllium copper alloys are supplied in strip up to 8 in. wide and down to 0.0005 in. thin, to tolerances as close as ±0.0001 in.—solution annealed or rolled to temper.

For further information circle No. 333 on literature request card on p. 32-B.

Immersion Heater

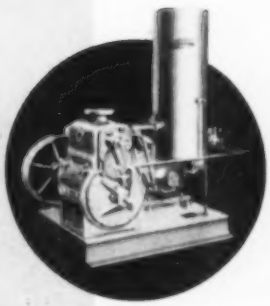
The new Glo-Quartz electric radiant immersion heater permits the heating of all acid electroplating, electropolishing, pickling and phosphatizing solutions with 100% efficiency regardless of the temperature or concentration of the solution. The smooth surfaced, fused quartz sheath is resistant to all acids except hydrofluoric. The units are available in a large range of sizes in various voltages.



For further information circle No. 334 on literature request card on p. 32-B.

Metalworking Machine

The new Newage Rindis performs over 50 different operations quickly, accurately, economically. The basic unit is universal insofar as it pro-



...for vacuum

Kinney High Vacuum Pumps — a big factor in the success of the titanium program — have been in the forefront on all types of vacuum work from the very beginning.

- **Kinney developed the first industrial size oil sealed mechanical vacuum pump.**
- **Kinney originated the rotating plunger vacuum pump — universally acclaimed for fast pump-down and quick recovery.**
- **Kinney offers the *big line* of vacuum pumps — 13 single stage and 4 compound models.**
- **More vacuum processes depend on Kinney Pumps than any other make of mechanical vacuum pumps.**

All Kinney district offices are staffed by qualified vacuum engineers who are ready to discuss vacuum with you in your plant. Kinney Manufacturing Co., — manufacturers of vacuum and liquid pumps. Representatives in principal cities of the U. S. and foreign countries.

SEND COUPON FOR DETAILS!

SUBSIDIARY OF THE NEW YORK AIR BRAKE CO.

Kinney

Kinney Manufacturing Co.
3584 Washington Street
Boston 30, Mass.

Please send Bulletin V-51B describing the complete line of Kinney Vacuum Pumps.

Name _____

Company _____

Street _____

City _____ State _____

Any furnace that needs accurate control

can afford the

Pulse PYR-O-VANE

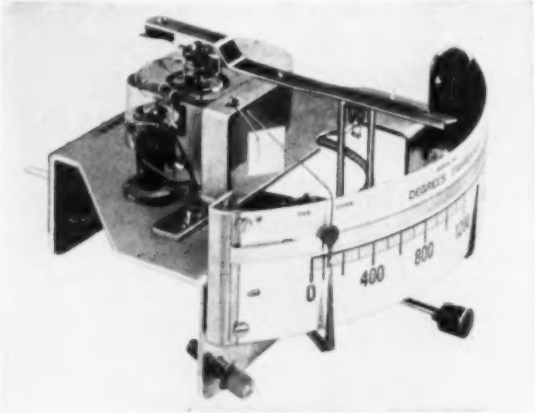
TEMPERATURE CONTROLLER

- provides time-proportioning control
- ideal for electric heating
- applicable to many fuel-fired furnaces
- simple, plug-in design
- economically priced

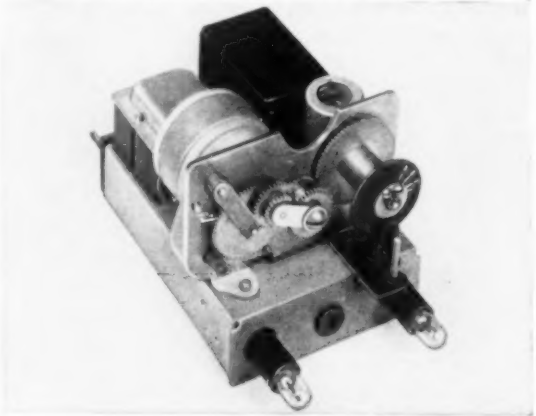
UNIT CONSTRUCTION SIMPLIFIES MAINTENANCE

All the working parts of the *PYR-O-VANE* Controller can be replaced in a matter of a few seconds. Both the galvanometer assembly and the control chassis are plug-in units which slide easily into place. All electrical connections are made automatically when the unit is inserted . . . no chance for wrong connections. Maximum continuity of operation is insured by keeping spare units on hand. In case of trouble, replacement is made so quickly that control is practically uninterrupted.

Galvanometer unit plugs into upper part of case.



Plug-in control unit fits into lower section of case. Interchangeable with two-position control unit.





THE compact, indicating Pulse *PYR-O-VANE* Controller now brings the full accuracy of proportional control within the reach of many processes. At remarkably low cost, it affords sensitive, flexible control beyond the capabilities of two- or three-position instruments.

This performance means higher production efficiency, decreased reject rates, faster heating-up time . . . all adding up to real savings that soon repay the original investment.

Proportional Control Prevents Temperature Cycling

The Pulse *PYR-O-VANE* Controller supplies heat input in pulses . . . and regulates the percentage of "on" time. It thus provides continuous, accurate variation of the average heat input to balance the requirements of the process.

This improved control brings the process up to temperature faster, without overshoot. And it holds temperature right where you want it . . . never allows it to wander.

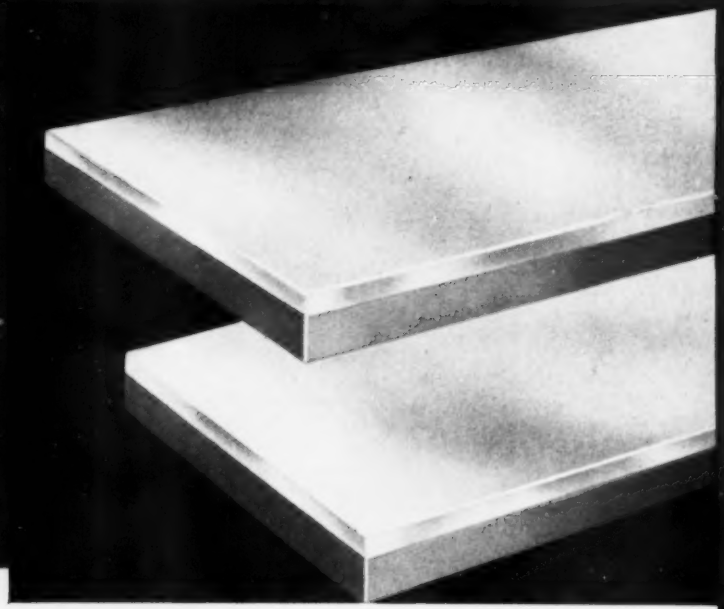
The Pulse *PYR-O-VANE* Controller will set new standards of performance for countless processes . . . probably many of those in your own plant. Ask your local Honeywell engineer to give you full details. Call him today—he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Phila. 44, Pa.

● **REFERENCE DATA:** Write for Bulletin No. 1052, "Pulse *PYR-O-VANE* Controller"

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

C F & I STAINLESS-CLAD PLATES



stainless steel advantages
... with carbon steel strength
... at lower cost

If you use stainless steel in your fabrication or construction, chances are you can lower your material costs substantially by means of C F & I Stainless-Clad Plates.

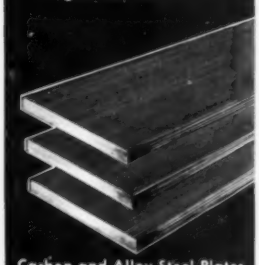
In numerous and diversified applications, these plates are giving all the advantages of stainless steel, including prolonged resistance to the corrosive action of acids and alkalis.

C F & I Stainless-Clad Plates are a composite of stainless steel permanently bonded to a carbon steel backing. Easy to fabricate, they will not buckle, crack or peel under the severest forming operations. To order, write or call Claymont Steel Products, Wickwire Spencer Steel Division, Claymont, Delaware.

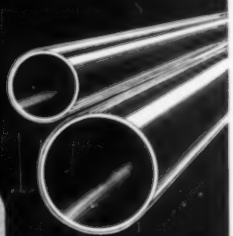
THE COLORADO FUEL AND IRON CORPORATION—Denver, Colorado
PACIFIC COAST DIVISION—Oakland, California
WICKWIRE SPENCER STEEL DIVISION—Atlanta • Boston • Buffalo • Chicago • Detroit
New Orleans • New York • Philadelphia
CANADIAN OFFICES: Toronto • Winnipeg • Edmonton • Vancouver



Flanged and Dished Heads



Carbon and Alloy Steel Plates



Large diameter steel pipe

CLAYMONT STEEL PRODUCTS
WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION CF&I

1210

duces all the movements and the full range of speeds expected from any type of machine tool. A whole range of accessories is supplied in the form of complete units. As soon as any of these units are fitted to the basic unit the entire setup becomes a single-purpose machine tool. The versatility of this machine is especially well suited to experimental and research laboratories, engineering shops, tech-



nical schools, model shops, and tool and die rooms. The wide range of work capable of execution makes it possible for the designer to follow his part through to completion, at little expense.

Even well-equipped machine shops find the machine extremely useful. When small runs or individual parts are needed they can be turned out without costly interruption of scheduled production, breakdown of setups, or costly delays. Change of accessories is accomplished in minutes. The drive from the motor gives a range of 24 spindle speeds from 65 to 2800 rpm.

For further information circle No. 335 on literature request card on p. 32-B.

Rare-Earth Elements in Stainless Steel

New facts concerning the effect of rare-earth metals and compounds on the hot workability of austenitic stainless steels have been developed by C. B. Post, chief metallurgist, and H. O. Beaver, metallurgist, of The Carpenter Steel Co. Addition of rare earths—particularly cerium and lanthanum—in the form of misch-metal produces effects different from those caused by rare-earth oxides. Essen-

New WAUKEE FLO-METERS

for accurately measuring air . . ammonia . . dissociated ammonia . . butane . . city gas . . endothermic cracked . . exothermic cracked . . hydrogen . . natural gas . . nitrogen . . oxygen . . propane.



Here's the most important advance in flo-meter design and construction in the last 20 years . . the new WAUKEE FLO-METER!

It's easier to see flow changes. It's easier to read . . has 6" scale. It's easier to clean . . complete hand disassembly takes only seconds.

It's easier to mount . . new design permits panel mounting, simpler piping. It has built-in control valves.

And you'll like the Waukee's streamlined appearance. For additional information request bulletin #201.

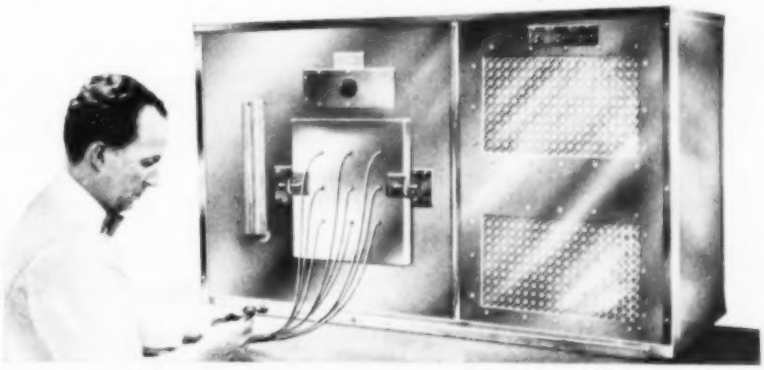
Waukee ENGINEERING COMPANY
759 Milwaukee Street, Milwaukee, Wis.

HIGH AND LOW TEMPERATURES
NEW BENCH-TYPE TEST UNIT

WEBBER
TRADE MARK REGISTERED
COMPLETE TEMPERATURE RANGE
TESTING UNITS

Combine high and low temperatures within the same cabinet with all controls self contained. Unit measures 50"x28"x20" with a testing chamber 12"x12"x12". Temperature range is from -80° F., to 185° F. Heat application is accomplished with reverse cycle refrigeration, which eliminates the hazards associated with open heating elements. A blower is provided for even distribution of temperatures and greater testing accuracy. Latch-type or hinge-type door optional. Accelerated pull-down to -80° in 30 minutes or less.

Write today for more complete information



INDUSTRIAL FREEZER DIVISION
WEBBER MANUFACTURING COMPANY, INC.
(Formerly Webber Appliance Co., Inc.)
2747 MADISON AVENUE - INDIANAPOLIS 3, INDIANA

Now— ALUMINUM SOLDERING MADE EASY!

A Universal Flux For All Commercial Metals Usually Joined By Soldering

WIRE SX PRODUCTS

Aluma-Flux SOLDERING FLUX

Manufactured By
ESSEX WIRE CORP.
Ft. Wayne, Ind.

Here at last is the only flux ever developed that makes possible the *non-corrosive* joining of all types of aluminum alloys by any soldering method—manual, dip or mechanical. No cleaning is required after soldering is accomplished—Aluma-Flux leaves no corrosive residue—soldered pieces are ready for use immediately.

S-X Aluma-Flux is equally effective for soldering stainless steel, bare and galvanized carbon steel, cast iron and other ferrous alloys, copper, brass and nickel—all commerical metals commonly joined by soldering. The joining of aluminum to brass; the coating of copper with tin; and the soldering of other unlike metals is made fast and easy with Aluma-Flux.

Soldered joints in aluminum produce no corrosive action due to flux residue when exposed to salt-spray, high humidity, alkaline water, etc. Aluma-Flux shows no detrimental effect on any soldered joint.

S-X Aluma-Flux can be used with 100% satisfactory results in powdered form as delivered, or in molten form—whichever is most efficient for the job. Virtually any type of solder can be used. Aluma-Flux can be stored indefinitely without change of weight, or any impairment of fluxing efficiency. Being non-hygroscopic, it will not absorb water.

In addition to its exceptional fluxing characteristics, Aluma-Flux offers many other cost-reducing, time-saving advantages . . .

The success of S-X Aluma-Flux in the soldering of aluminum is due to the action in which the flux initially reduces surface oxides and then immediately deposits a thin layer of plating material on the solder area. Oxidation of the area to be soldered is thus prevented while the plating material serves as an approved base on which to solder. In addition to its soldering efficiency, Aluma-Flux reacts completely during the joining operation so there are no corrosive flux residues to lower corrosion resistance of the finished joint.

ALUMA-FLUX IS READY FOR IMMEDIATE SHIPMENT IN CONVENIENT SIZE METAL CONTAINERS.

Write Today For Complete Details

Distributed Only By

INSULATION and WIRES incorporated

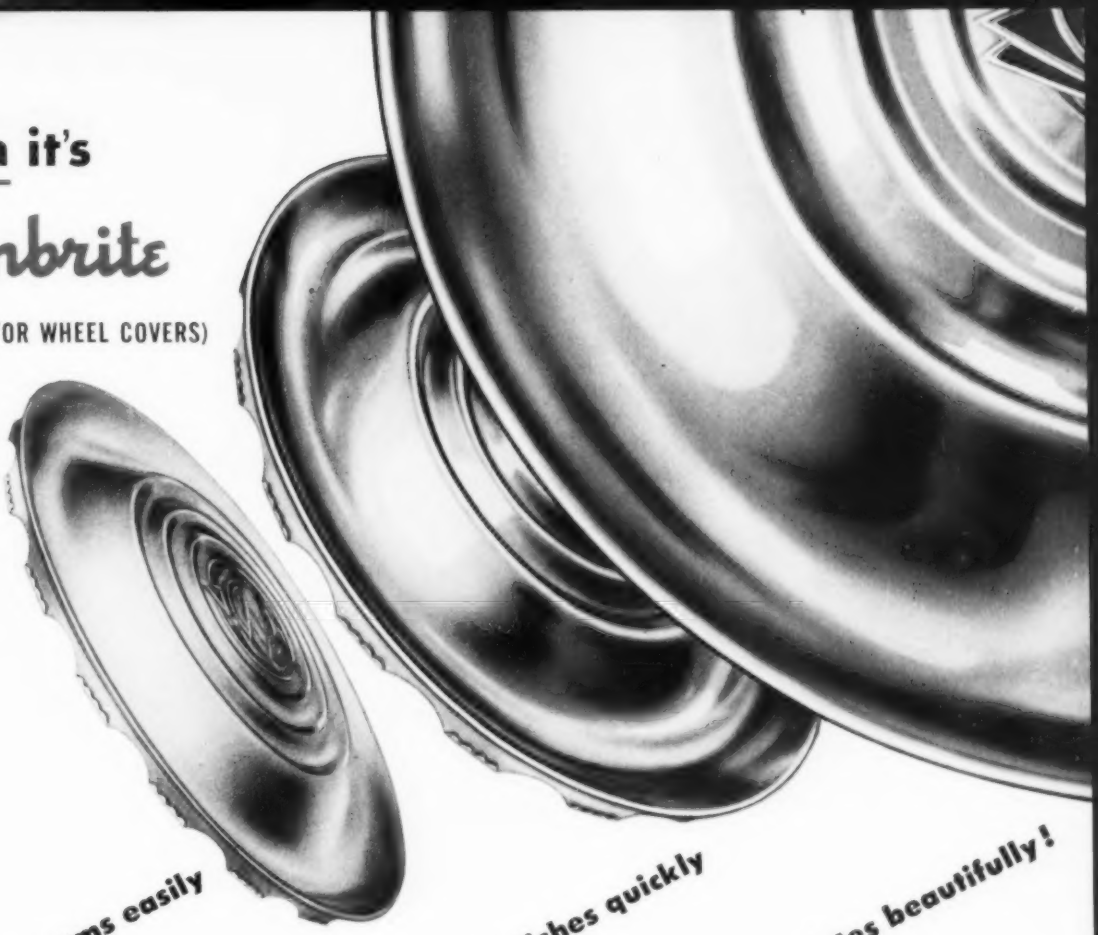
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1535A Swinney Avenue • Ft. Wayne 6, Indiana

again it's

Formbrite

(THIS TIME FOR WHEEL COVERS)



● it forms easily ● polishes quickly ● plates beautifully!

Canadian Motor Lamp Co., Limited, Ford, Ontario, is a large automotive parts supplier. When Canada's "Big Three" turned to full wheel covers in place of hub caps for many '53 models this supplier, suddenly facing a new set of production problems, turned to Formbrite*, exceptionally fine-grain Anaconda Brass. Here are the reasons:

1 Previous experience in manufacturing large quantities of chromium-plated brass hub caps made of Formbrite indicated that polishing operations could be reduced as much as 50%.

2 Formbrite had demonstrated its remarkable ductility for press operations—taking sharp, clean-cut, ornamental die impressions.

3 Formbrite was harder, stronger, springier and more scratch-resistant than ordinary drawing brass . . . desirable characteristics for the service involved.

4 Important, too, was the fact that Formbrite would provide the fatigue-resisting springiness to the gripping fingers that hold the cover to the wheel.



Shown above is one of the 16 sets of gripping fingers which hold the 15" diameter wheel cover to the rim. The metal is yellow brass, .024" thick, supplied in coil as Formbrite.

Now in full production on the new wheel covers, Canadian Motor Lamp's appraisals proved 100% correct. Maybe *you're* missing something by *not* using Formbrite. Write for Publication B-39, addressing The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.

*Reg. U. S. Pat. Off.

5390

Formbrite DRAWING BRASS

An **ANACONDA** product made by The American Brass Company

PRESSURE

It's big business at U.S. Gauge where **brass** belongs

At Sellersville, Pa., millions of pressure gauges are made each year—for every type of industry—to every degree of accuracy—and for pressures ranging from a few ounces per square inch up to 100,000 pounds.

With each gauge a precision instrument unto itself, it's quite a job to maintain the high standards of routine fabricating procedure on each of its many components. Part of it depends on having just the right copper alloy in the most satisfactory combination of chemical and physical properties. That's where teamwork between U. S. Gauge and Anaconda Metals has been clicking day after day, year after year.

and now—something NEW has been added . . .

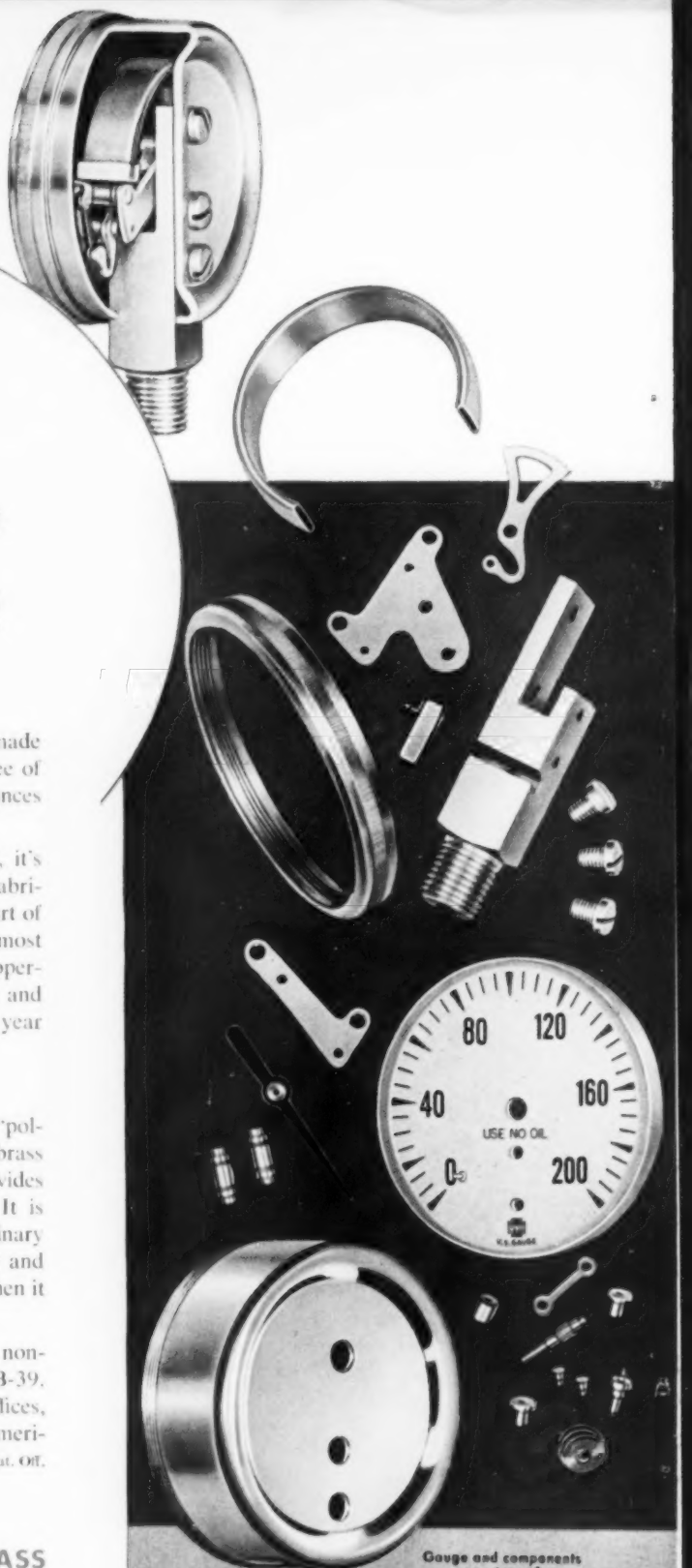
U. S. Gauge is now using Formbrite* for many of its "polished and lacquered" and chromium plated solid brass gauge cases. Formbrite, with its superfine grain, provides a surface far superior to ordinary drawing brass. It is stronger, harder, more scratch-resistant than ordinary brass, yet retains remarkable ductility for forming and drawing. Best of all, Formbrite is a real time saver when it comes to finishing operations.

Want to know more about this "premium product at a non-premium price"? Write for Anaconda Publication B-39. Address: The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. *Reg. U. S. Pat. Off.

Formbrite DRAWING BRASS

An **ANACONDA** Product

Made by The American Brass Company



Gauge and components courtesy of

UNITED STATES GAUGE

DIVISION OF AMERICAN MACHINE AND METALS, INC.

Sellersville, Pa.

For the ultimate in precision, eleven different Anaconda Alloys in the form of rod, tube, sheet and strip are used in producing the components of the U. S. Gauge illustrated above.

tially, the difference is that mischmetal additions leave small amounts of cerium and lanthanum in the steel which substantially improve hot working properties. Rare-earth oxides improve existing hot working properties while leaving no trace of cerium and lanthanum in the steel. The investigators conclude that rare-earth oxides improve the hot workability of inherently ductile austenitic stainless steels, but do not improve the hot-workability of hot-short or hard-to-work grades of austenitic stainless steels.

For further information circle No. 336 on literature request card on p. 32-B.

Rod Cutting

A new and improved Di-Acro power rod parter for speedily and accurately cutting or "parting off" rods and bars (from $\frac{1}{8}$ to $\frac{5}{8}$ in.) without burr and distortion has been announced by O'Neil-Irwin Mfg. Co. Principal improvement is the replacement of an



air-operated power unit with a motor-driven flywheel. The flywheel drive, operating at 180 strokes per min., provides six times the cutting speed previously available. An Ejectomatic gage, supplied as standard equipment, allows the separate operations of gaging, ejecting and cutting to be performed in a single working cycle.

For further information circle No. 337 on literature request card on p. 32-B.

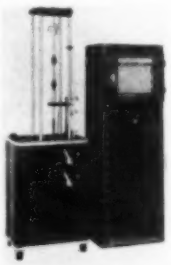
Chemical-Resisting Coatings

New formulations which can be spray-applied to produce extra-thick chemical-resisting coatings on steel and other metals have been developed by United Chromium, Inc. These products, identified as Unichrome 5300 coatings, are used to protect equipment against acids, alkalis, salts, oxidizing agents and many other corrosives. The new coatings, used at room temperature, can be applied to cold vertical surfaces to produce single-coat dry films up to 20 mils thick. Even at these unusual thicknesses, practically no sagging is encountered. Materials previously offered for similar applications usually provided single-film dry thickness of about 1 mil, seldom more than 6 mils.

For further information circle No. 338 on literature request card on p. 32-B.

Tensile Tester

Thwing-Albert Instrument Co. announces a new electro-hydraulic tensile tester. It is simple and rapid for routine production and quality control work in the plant, and accurate and flexible for the research laboratory. It has a rigid crosshead and uses strain gages for load measurements. Full-scale load ranges from 5 g. to 5000 lb. are available. Rates of extension from 0.1 to 20 in. per min. are standard. Special ranges from 0.2 to 250 in. per min. have been provided. The electronic recorder and controls are in a separate cabinet that can be moved about with respect to the tester. A larger model is available for load ranges to 10,000 lb.

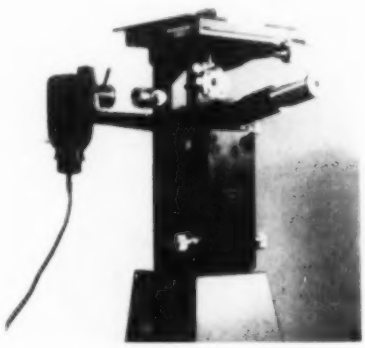


For further information circle No. 339 on literature request card on p. 32-B.

Inverted Metallurgical Microscope

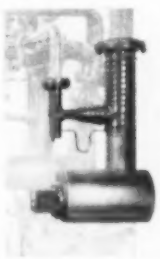
The Reichert Melabor inverted microscope, available from William J. Hacker & Co., Inc., comes on a large stable base equipped with shock absorbers. Mechanical stage is 15 cm. square; accessories include binocular eyepiece attachment and microhardness tester.

For further information circle No. 340 on literature request card on p. 32-B.



Vacuum Pump

Consolidated Vacuum Corp. has announced another addition to its line of high-vacuum pumps. The new unit is designated as the Type KS-600 ejector diffusion pump. Designed to produce a high pumping speed over the pressure range of 1×10^{-3} to 5×10^{-5} mm. Hg, it will remove air at a rate of 1200 cu.ft. per min. in the pressure region from 10^{-2} to 10^{-4} mm. Hg. It combines an oil diffusion jet and a single-stage oil ejector nozzle in one compact casing to produce an ultimate pressure of 10^{-5} mm. Hg while operating against a limiting forepressure of 0.5 mm. Hg.



For further information circle No. 341 on literature request card on p. 32-B.

Portable Hardness Tester

The Penetrascope, an adaptable portable hardness tester, is now being sold exclusively in this country by C. Tennant, Sons & Co. The instrument tests ferrous and nonferrous metals in a wide range of sizes and shapes



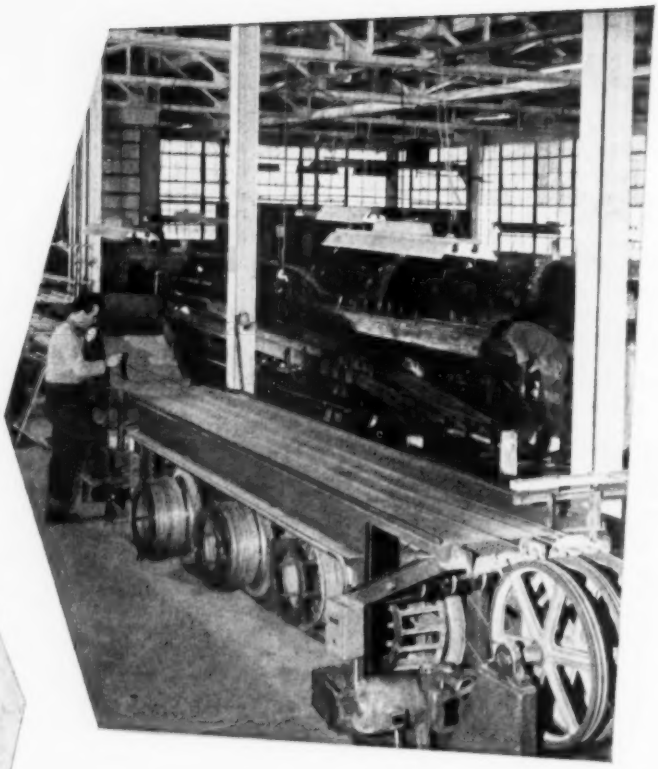
and is used on large or small work in place, in the shop or laboratory. The tester has a 135-deg. pyramidal diamond indenter. The load can be set at any point from 1 to 30 kg. Ball-type indenters of 1 and 2 mm. diameters are supplied for testing cast iron and other large-grained metals.

For further information circle No. 342 on literature request card on p. 32-B.

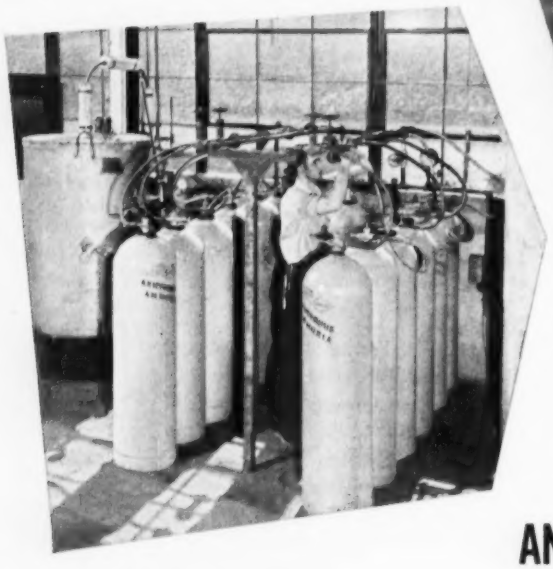
Stainless Steel Soldering Flux

Remont Mfg. Co. has announced a soldering flux especially for use on stainless steel, Monel, Inconel, Nichrome, chromium, manganese, molybdenum, tungsten and vanadium alloys. Low thermal conductivity and a persistent oxide film usually cause diffi-

As an economical source of hydrogen for annealing of stainless steel tubing...



Tubing leaving the annealing furnace through a sand curtain at J. Bishop & Co., Malvern, Pennsylvania



Cylinders are easily handled . . . take up minimum of working space.

J. Bishop & Company dissociates Du Pont "National"* ANHYDROUS AMMONIA IN CYLINDERS 99.99% AMMONIA

One 150-lb. cylinder of Du Pont "National" Anhydrous Ammonia, when dissociated, gives the equivalent of 1710 cu. ft. of nitrogen and 5100 cu. ft. of hydrogen at atmospheric pressure. The nitrogen and hydrogen thus gained at low cost are combined with natural gas to form an inert atmosphere for annealing stainless steel tubing.

Bishop & Co. uses Du Pont "National" because the high purity—99.99% ammonia—makes possible a more inert atmosphere and means fewer shutdowns for removing oil deposits from catalysts used in dissociating. They also find Du Pont "National" cylinder ammonia convenient to handle . . . takes up little working and storage space.

Du Pont "National" Anhydrous Ammonia is always uniform, always dependable, always dry—with a moisture content of less than 50 parts per million. It is immediately available from distributors and stock-points conveniently located across the country. E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Wilmington 98, Del.

*REG. U.S. PAT. OFF.

DISTRICT OFFICES:
350 Fifth Avenue, New York 1, New York
7 S. Dearborn Street, Chicago 3, Illinois
818 Olive Street, St. Louis 1, Missouri

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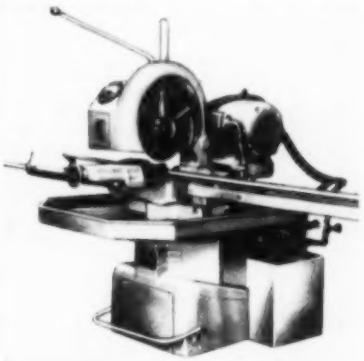
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culty in soldering stainless steel. This new flux removes oxides without affecting corrosion properties and assists solder to flow at the lowest possible temperatures. It is suitable for solder-iron, flame or dip soldering.

For further information circle No. 343 on literature request card on p. 32-B.

High-Speed Cut-Off Machines

The Ballinger division of Douglas Export-Import Corp. is introducing a newly developed line of cut-off machines in this country. These machines are a new application of normal, wet



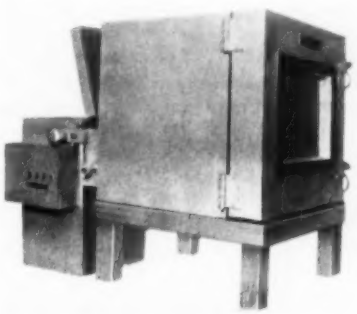
cutting, bonded abrasive wheel cutters. Cutting speeds are stated to be as follows:

3 in. dia. high speed steel	54 sec.
3 in. dia. x 2½ in. bore high speed steel	12 sec.
¾ in. boron carbide	240 sec.
9 x 3 in. U section steel channel	58 sec.
6 x 2½ in. bull head rails	105 sec.

For further information circle No. 341 on literature request card on p. 32-B.

Environmental Test Units

Tenney Engineering, Inc. has announced a standard line of high and low-temperature environmental test equipment comprising servo unit and companion test chamber. The equip-



ment furnishes controlled temperatures for conducting tests. A simple attachment will maintain relative humidity from ambient to 95% in a temperature range from ambient to 180° F. The servo unit is a portable air conditioning unit which can provide air circulation of 40 cu.ft. per min. At −100° F. this circulation will absorb 1700 Btu. per hr. At temperatures to 185° F. this circulation is capable of delivering 5000 Btu. heating effect. Low temperatures are achieved by circulating air over dry ice; high temperatures, by circulating air around electric heaters. The companion chamber, an insulated chamber in which tests are actually conducted, is attached to the servo unit by means of a simple fastening device which may be disconnected to permit the servo unit to be used as a source of conditioned air for other enclosures.

For further information circle No. 345 on literature request card on p. 32-B.

X-Ray Inspection

A new type of industrial fluoroscope was featured by General Electric Co., X-Ray Dept., at the recent Western Metal Congress. Known as the Scopemaster, it is designed for the mass inspection of light alloy castings. A single external control handle permits



moving of parts to be inspected in any lengthwise or crosswise direction while in the X-ray beam. The distances between the receiving screen and the product part may also be adjusted. Internal cavities approximately 6% of the metal thickness can be detected in aluminum alloy castings.

For further information circle No. 346 on literature request card on p. 32-B.

Copper Purifier

A new copper purifier, which eliminates the need for periodic dumping of copper plating baths by removing harmful solution breakdown impurities and converting them to useful cyanides, has been announced by Sel-Rex Precious Metals, Inc. The purifier is a concentrated solution of pure salt

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prepared especially for use in cyanide copper plating solutions. Addition of one gallon of copper purifier will remove at least 38 oz. of sodium carbonate or 50 oz. of potassium carbonate. It will increase the sodium cyanide content of the bath by at least 35 oz. or the potassium cyanide content by at least 47 oz.

For further information circle No. 347 on literature request card on p. 32-B.

Heliarc Welding Torch

A water-cooled torch for inert-gas-shielded arc welding is announced by Linde Air Products Co. The torch has a rated capacity for continuous duty of 300 amp. and either high-frequency stabilized alternating current or straight polarity direct current can be used. It is designed for welding practically all commercial metals up to about ⅛ in. thick. Water is circulated to the torch head, through the water jacket, back through the head again, and out through the power cable. This improved water-cooling



system minimizes electrode stub loss since the collet body is brought closer to the arc without damage from excess heat. Electrodes can be changed or adjusted in only a few seconds.

For further information circle No. 348 on literature request card on p. 32-B.

High-Purity Iron

Plastic Metals Div. of National Radiator Co. has announced the availability of electrolytic iron of 99.84% purity. It is especially adapted to use as melting stock for production of ferrous alloys of closely controlled composition. Carbon content is 0.018%; other elements are below 0.010% each, except oxygen, which is 0.070%.

For further information circle No. 349 on literature request card on p. 32-B.

SR-4 Strain Indicator

A new Model M Baldwin portable SR-4 strain indicator has been announced by Baldwin-Lima-Hamilton Corp. The instrument is designed for operation with either batteries or a-c. power pack, which is optional equipment. The new a-c. power pack unit fits into the battery compartment



and is mounted on a separate back cover of the instrument case. The Model M is functionally identical to the previous Model L. The indicator reads directly in micro-inches per inch up to 30,000.

For further information circle No. 350 on literature request card on p. 32-B.

Solution Control

Instrumentation that permits automatic feeding of treating chemicals either to maintain uniform concentrations or to correct variations of pH in any continuous process has been announced by The Foxboro Co. Since transmission and control are completely pneumatic, the system of automatic feeding offers maintenance economy, accuracy and operating simplicity. Any number of supplementary indicators, recorders or controlled diaphragm feeders can be operated from one pneumatic signal, permitting unlimited combinations of information and control.



For further information circle No. 351 on literature request card on p. 32-B.

Alloy for Electronics

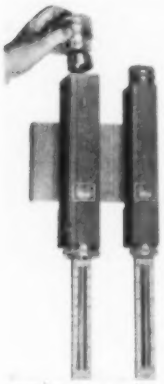
Battelle scientists have reported the development of a low-cost metal combination that may compete with germanium and silicon for use in transistors, rectifiers and other electronic devices. The potential competitor is a compound of aluminum and antimony.

It is one of several that may come from compounds of aluminum, gallium, and indium with arsenic and antimony. Rectifiers have already been produced in the laboratory with the new semiconductor material and its use in the making of transistors is considered a distinct possibility.

For further information circle No. 352 on literature request card on p. 32-B.

Flow Meter

Waukee Engineering Co. has announced a built-in-control-valve version of the standard Waukee flow meter. Built-in-valve models are available in 11 different sizes. Valves are located at top of meter for easy and quick reading. There is no need to drill holes for the control valve when equipment is to be panel mounted. Meters are available for measuring air, ammonia, butane, carrier gas, city gas, dissociated ammonia, endothermic gas, exothermic cracked gas, hydrogen, natural gas, oxygen, propane and purging gas. Each meter includes built-in calibration for the specific gas and the flow rate to be measured.



For further information circle No. 353 on literature request card on p. 32-B.

Comparator Densitometer

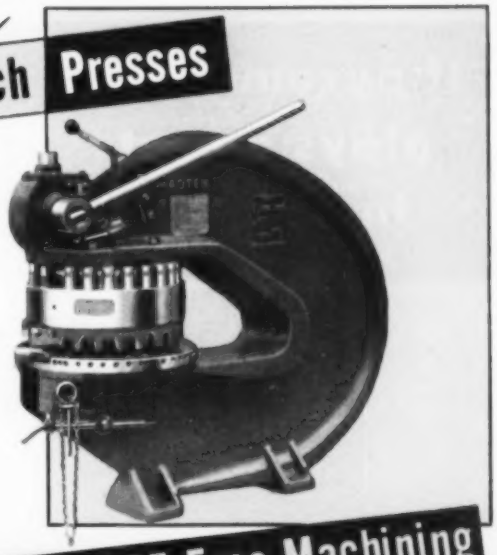
Baird Associates' comparator densitometer, newest accessory for emission spectroscopy, is a double-beam automatic servo-type instrument, calibrated to read photographic densities directly on a linear scale. Density is measured by obtaining a null balance with a comparison beam which has passed through accurately calibrated logarithmic apertures driven by a servo-system. The line to be measured is located with a comparison spectrum on a scale at 10 × magnification. The range is zero to 2.00; smallest scale division is 0.01 density unit; reproducibility is ±0.003.

For further information circle No. 354 on literature request card on p. 32-B.

Tin Thickness Gage

Applied Research Laboratories have announced a contract with Jones & Laughlin Steel Corp. for the production of a revolutionary tin plate thickness gage. This instrument, engineered by Jones & Laughlin, uses

Rotex Punch Presses

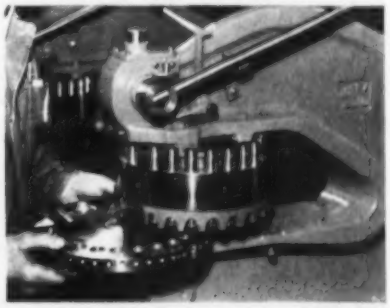


Have SPEED CASE Free Machining Plate Steel Die Turret Plate

SPEED CASE (X1515) low carbon, open hearth, steel plate has won the favor of numerous manufacturers of machine tools, because of its machinability, ease of finishing and response to various case hardening methods.

Typical is Rotex Punch Co., Oakland, Calif., who adopted **SPEED CASE** for the die turret plate on their versatile presses. They report ease of machining, longer tool life and negligible distortion in heat treating.

The die turret plate retains the dies which are readily removed and replaced. At a flick of the wrist a different size punch can be brought into position. The turret die plate is then rotated to the desired position and locked in place. Rotex "Quick Change" Punch Presses are widely used in sheet metal, fiberboard, plastic and other fabricating plants. Punches and dies may be round, square or other shapes. **SPEED CASE** has ideal physical properties for this application. Perhaps it can save time, cut costs on your equipment. Send for facts.



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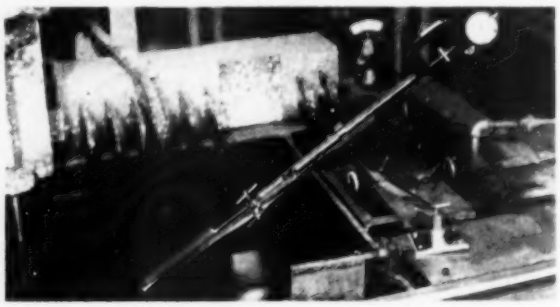
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

the X-ray principle for measurement of thickness of tin on steel to accuracies of one millionth of an inch, making such measurements automatically while tin plate is traveling at high speeds as a continuous sheet on the production line. The instrument will have application to many problems in the tin can, aluminum foil and other fields.

For further information circle No. 355 on card, p. 32-B.

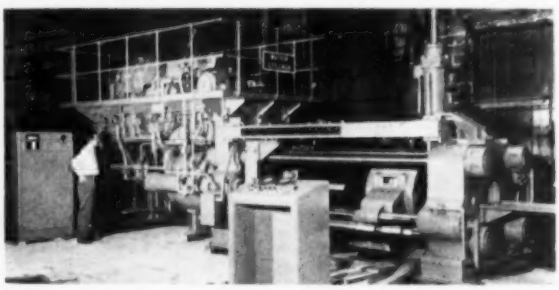
Dilatometer

The Ajax Electric Co. has investigated the merits of the Schaaber dilatometer, developed in Germany. With the greatly expanding use of martempering and austempering in heat treating, this instrument offers product control possibilities such as more accurate and quicker



determinations of (1) transformation time for austempering; (2) martempering time cycles available before transformation begins; and (3) the severity of the quenching medium. It also serves as a control check of steels.

For further information circle No. 356 on card, p. 32-B.



Aluminum Extrusion Press

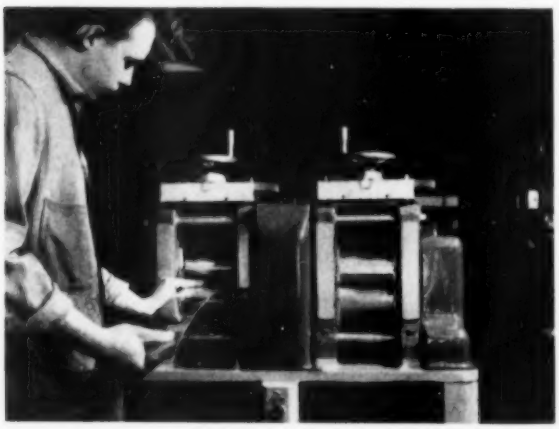
A new 1250-ton long-stroke aluminum extrusion press manufactured by The Watson-Stillman Co. is capable of handling billets up to 24 in. long. The long-stroke design of the main cylinder permits loading billet and dummy block into the container on a single forward stroke of the main ram. The ram moves at the rate of 8 in. per sec, and loads a 24-in. billet and dummy block in 4 sec.

For further information circle No. 357 on card, p. 32-B.

Small Rolling Mills

A new concept in the design of small rolling mills — with ruggedness and versatility the main objectives — is embodied in a new line of 3 and 4-in. mills developed by the Stanat Mfg. Co. Versatility is achieved by mounting standard units side by side on a single base in various combinations. Typical groupings are: Two sets of flat rolls, one for roughing, one for finishing; one set of flat rolls and one set of wire rolls; two sets of wire rolls to increase the range of the machine; two sets of flat rolls, one for hot rolling and one for cold rolling. These mills can also be furnished with a built-in bull-block to draw wire, or to provide tension during rolling.

The rugged construction is characteristic of heavy equipment design. These features include housings cast of Meehanite and heavy bronze bearings, completely enclosed within a welded steel cabinet-type base. In addition, 4-in. units are available with roller bearings and can be arranged for water cooling. The mill has been used by

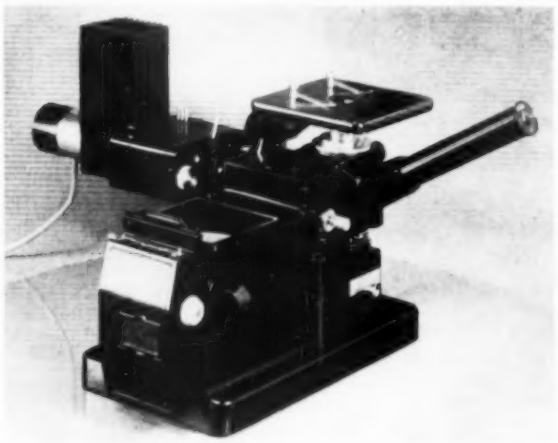


manufacturers of electronic tubes and wires, slide fasteners, tubular heating elements, optical parts, and jewelry. Laboratories are using them to test the properties of stainless steel, titanium and new experimental alloys.

For further information circle No. 358 on card, p. 32-B.

Microscope-Metallograph

A newly designed Galileo metallurgical microscope and metallograph has been announced by Opplem Co. The unit occupies only 1/10 to 1/20 of the space normally taken by instruments used for this type of work. Group observation of the specimen is made possible by projecting the light beam through the camera housing onto a screen. By utilizing the inverted design all operations are confined to an area of 13 x 8 x 8 in. The instrument provides all magnifications up to 1000 × and photographic and projection



observation up to 1500 ×. A 2½ x 3½ in. reflex camera is supplied which takes both plates and roll film. Seven interchangeable photographic lenses are supplied to cover the full range of magnifications up to 1500 ×. Exact focusing of the reflex camera is done on the horizontal ground glass screen and a precision-built shutter provides time, bulb and a wide range of exposures from one second to 1/250 of a second.

For further information circle No. 359 on card, p. 32-B.

Why Brass Sinterings *for* These Camera Parts?



In designing the film-loading door knob and key (see close-up photo) for the "80" Cine Camera, engineers of the Revere Camera Company deviated from stainless steel extrusions — the usual metal and production method for similar parts — in favor of brass sinterings. Why?

The answer is, of course, impressive production savings over and above the lower material cost of brass as compared with stainless steel. Working closely with the Chicago Powdered Metal Products Company technicians, the pictured camera parts were designed specifically for powder metallurgy. The required close hole diameters and counterbore steps were maintained at much less cost than by the usual production method. The simple drilling of holes to prepare the brass sinterings for assembly also proved to be more economical than with steel.

Satin chrome plating of these parts is necessary for appearance considerations but, since brass sinterings are corrosion resistant, a light coating is sufficient and, hence, finishing costs are kept at a minimum

To provide designers, engineers and metallurgists with a concise reference to the factors which should be considered in designing for powder metallurgy, we—the makers of Horse Head metal powders—have published a 32-page handbook FACTS ABOUT PRESSED BRASS and other non-ferrous POWDER PARTS. Ask us for a copy.

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360. Abrasive Belt Finish
32-page book gives 46 case studies on abrasive-belt methods which saved on machining. *Porter-Cable*

361. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

362. Allowable Stresses
Data Card 154 gives max. allowable stress values for 22 types of steel tubing. Formulas for calculation of max. working pressures. *Babcock & Wilcox*

363. Alloy Castings
8-page bulletin on alloy castings for heat treating. *Ohio Steel Foundry*

364. Alloy Selection
Chart to select alloy for given corrosive problem. 350 corrosives included. *Cooper Alloy Foundry*

365. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

366. Alloy Steel
68-page "Aircraft Steels" book includes revised military specifications. Also stock list. *Ryerson*

367. Alloy Steel
40-page book on heat treated alloy steel plate for maximum abrasion and impact resistance. Details on uses; 12 pp. of technical data. *Jones & Laughlin*

368. Alloy Tools
44-page book on cast Stellite tools for metal cutting. *Haynes Stellite*

369. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

370. Aluminum Extrusions
Data on services in the field of aluminum extrusions. *Himmel Bros. Co.*

371. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

372. Ammonia Atmospheres
12-page bulletin B-52 on dissociated ammonia furnace atmospheres. *Drever*

373. Ammonia for Heat Treat
Booklets on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "Nitriding Process", "Carbonitriding". *Armour*

374. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys". *International Nickel*

375. Anodized Coatings
Bulletin 894 on equipment for testing strength of anodized coatings on aluminum. *General Electric*

376. Anodizing
Data on aluminum racks with copper hooks for anodizing. *National Rack*

377. Anodizing Magnesium
Article on a new anodic coating for magnesium. *Dow Chemical*

378. Arc Furnace Control
8-page bulletin on furnace regulator that automatically balances arc current with arc voltage in metal melting. *Allis-Chalmers*

379. Atmosphere Furnaces
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

380. Automatic Molding
Bulletin MM on fully automatic unit for foundry molding. *Spo, Inc.*

381. Automatic Polishing
14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

382. Barrel Finishing
22-page book on single-unit installation to yield savings up to 95% in finishing various parts. *Almco Div.*

383. Barrel Plating
Folder on barrel plating with unique contact arrangement for maximum current distribution. *Daniels*

384. Metal Powders

Extensive and varied information about metal powders, abrasives and pigments is presented in this 256-page loose-leaf catalog.*

The section on powdered metals gives a general description of the process of making parts in powdered metal. Tailoring of metal powder properties to suit a variety of applications is discussed. The section concludes with a 10-page glossary and an 18-page bibliography for further reading.

A section on abrasives concerns recommendations, tolerances, specifications, definitions and illustrations of metal shot and grit.

An 80-page section shows the many applications of aluminum, bronze and gold pigments in several industries to a variety of products and uses. The properties and evaluation of pigments are discussed generally, for instruction of the nonexpert. It is useful to present users in giving application, handling and composition data. A 17-page glossary is included.



*Published by Metals Disintegrating Co., Inc. Copies are available at no charge to readers of Metal Progress who circle No. 384 on request card, page 32B.

385. Bending and Cutting
Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

386. Beryllium
20-page booklet describes beryllium products, including the pure metal, oxide and alloys. *Beryllium Corp.*

387. Beryllium Copper
Helpful engineering information contained in monthly beryllium copper technical bulletins. *Beryllium Corp.*

388. Bimetal Applications
32-page book on application of thermostatic bimetal. Property charts for 30 types. Design formulas. *W. M. Chace*

389. Black Oxide Coatings
Data on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

390. Black Oxide Finish
Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

391. Blast Cleaning
24-page Bulletin 400 on blast cleaning installations for large work. *Pangborn*

392. Braze-Carburize
Article on simultaneous brazing and carburizing of hand tools. *Ajax Electric*

393. Brazed Tubing
12-page data book on brazed tubing made from copper-coated steel. *Bundy*

394. Brazing
50-page text GEA-3193 describes the methods and applications of electric-furnace brazing. *General Electric*

395. Brazing Applications
48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

396. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

397. Bright Annealing
Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

398. Burners
16-page bulletin on selection of gas burners. *Western Products*

399. Burners
Bulletin on combination gas and oil burner. *Ra-Diant Products*

400. Burners
8-page Bulletin H-9 on injector-type box burners for low, medium or high pressure gas and natural draft. *Eclipse*

401. Burners
Bulletin 123 on new series of burners for multi-purpose furnaces. *North American Mfg.*

402. Carbide Segregation
Effect of carbide segregation in tool steel. *Latrobe Steel*

403. Carbon Control
Catalog T-623 describes the Microcarb control system that continuously measures the active carbon in the furnace atmosphere during heat treatment. *Leeds & Northrup*

404. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Engineering*

405. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

406. Carburizing
16-page bulletin SC-134 reviews gas carburizing techniques and possibilities. *Surface Combustion*

407. Carburizing Salts
Folder on salts for liquid carburizing. *Swift Industrial Chemical*

408. Castings
20-page bulletin gives standard shapes available in cast iron, brass and aluminum. *Myerstown Foundry & Machine*

409. Castings, Bronze
16-page booklet on sand and centrifugal castings. *Amer. Non-Gran Bronze*

410. Centrifugal Castings
62-page book on centrifugally cast iron, steel, gray iron parts. ASTM specifications. *American Cast Iron Pipe*

411. Centrifugal Castings
12-page bulletin on steel shapes made by centrifugal casting in metal mold. *Lebanon Steel Foundry*

412. Chemical Polishing
Data Sheet 32 on new one-minute chemical immersion process for polishing steel. *MacDermid*

413. Chromate Coatings
Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

AMONG A TOOL STEEL SALESMAN'S SOUVENIRS



Here's a punch and a slug — not an unusual punch but one with a history of accomplishment.

A good customer, during the hectic days of World War II, had difficulty getting a 1¾" diameter hole in about 2000 pieces of hot rolled plate 1¼"x8"x8" in a hurry. The finished product was a hook-eye to be welded atop buoys, on a Navy job. Burning and drilling were tried but were too slow. With great apprehension a punch and die were made, using Ziv's PLANCHER Tool Steel. The 2000 holes were promptly punched, cold, without a hitch, and both punch and die were good for a good many more.

While you may not be punching 1¼" thick hot rolled plate, you may have other jobs calling for a tough, resilient tool steel, built to be tough, real tough, then it is wise to use Ziv's PLANCHER Silicon Manganese Tool Steel.



Photo Courtesy of Mesker Bros. Iron Co. St. Louis, Mo.

ESTABLISHED 1911

ZIV STEEL & WIRE CO.



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414. Cleaning
12-page Bulletin 68 deals with factors to consider in selecting metal cleaning equipment. *Despatch Oven*

415. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

416. Cleaning Equipment
Folder on degreaser. Data on different models. *Topper Equipment*

417. Color-Coded Temperature Records
Bulletin 427 describes instrument that records up to six temperatures on a single circular chart, each record in a different color. *Foxboro*

418. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

419. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

420. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

421. Controllers
80-page Catalog 8305 on nonindicating electric, electronic and pneumatic controllers for temperature, pressure and humidity. *Minneapolis-Honeywell*

422. Copper Alloys
124-page data book on wrought copper alloys. *Chase*

423. Corrosion Control
8-page booklet on use of nickel-lined pipe and fittings. *Bart Mfg.*

424. Corrosion-Proof Cement
12-page bulletin gives corrosion resistance of four types of cement vs. 176 chemical solutions. *Atlas Mineral*

425. Corrosion Protection
Bulletin on Flamespray process for applying protective coatings to exposed metal surfaces. *Bondwell*

426. Corrosion Resistance
32-page brochure on causes of corrosion and means of combating them. Choice of materials for condenser tubes. *Revere Copper & Brass*

427. Corrosion Resistance
New chart indicates resistance of seven classes of corrosion resistant cements to 297 of the most generally used corrosive chemicals. *Pennsylvania Salt*

428. Corrosion Resistance
35-page booklet on plastic materials of construction. *Atlas Mineral Products*

429. Corrosion Resistance
20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

430. Crystal Models
Folder describes unique kit for constructing crystal models. *Harshaw*

431. Cutting Off
8-page bulletin on circular saw blades for cutting off. *Motch & Merryweather*

432. Cutting Oil
Shop notebook gives important facts on right cutting fluid for any machining operation. *D. A. Stuart*

433. Definitions
36-page glossary of over 150 terms on cast iron. *International Nickel*

434. Degreasing
Pamphlet on properties and use of trichlorethylene. *Niagara Alkali*

435. Design of Dies
32-page bulletin on design of dies for

upset forging. Also rules for upsetting and examples of forgings. *Ajax Mfg.*

136. Desulphurization
20-page reprint ADR 81 on calcium carbide injection gives data on application to molten cast iron. *Air Reduction*

137. Die Casting
Bulletin 103 describes new cold chamber die-casting machine with capacity of 9.5 lb. of aluminum. *Lewis Welding & Engineering*

138. Die-Casting Machines
22-page catalog shows complete line of die casting machines. *Kux Machine*

139. Die-Casting Machines
Illustrated booklet giving specifications, application data and full explanations of two new production advantages on company's line of die-casting machines. *Lake Erie Engineering*

140. Dipping Baskets
Bulletin describes 20 types of cleaning, dipping and degreasing baskets. *Hoffman Co.*

141. Drawing Compounds
Folder on lubricant for forming and drawing of stainless. *Hangsterfer*

142. Ductile Iron Castings
12-page bulletin on pearlitic, ferritic and austenitic grades of ductile iron. 12 typical uses. *American Brake Shoe*

143. Electric Furnaces
Bulletin 473 on automatic melting machine for ferrous and nonferrous alloys. *Detroit Electric Furnace*

144. Enamel Coatings
Reprint gives data on thin porcelain enamel coatings on aircraft exhaust systems. *Porcelain Enamel Institute*

145. Fabricating Aluminum
24-page bulletin, a catalog of facilities available for fabricating service. *Reynolds Metals*

146. Fatigue Testing
12-page bulletin on Schenck universal dynamic fatigue machines for oscillating reversed stress, push-pull fatigue testing, torsion tests, single-direction stressing and endurance life tests. *R. Y. Ferner Co.*

147. Finishing
Bulletin on continuous filtration for paint spray booth water. *Industrial Filtration Co.*

148. Finishing
28-page catalog B-9 on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

149. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

150. Finishing
Catalog A-653 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

151. Flaw Detection
12-page bulletin on location of flaws by two dye-penetrant inspection methods. *Turco Products*

152. Flow Meters
24-page manual on application and installation of indicating flow meter. *Meriam Instrument*

153. Flow Meters
Bulletin on gas flow meter for furnace installations. *Hays Corp.*

154. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g.*

155. Forgeability
112-page book, "Evaluating the Forgeability of Steels". Hot work characteristics in chart form for 94 steels. *Timken*

156. Forging Manipulators
Folder on manipulators for automotive, ordnance, aluminum and specialty forging. *Salem-Brosius*

157. Forgings
20-page Catalog 51 on various types of forgings, their strength and related data. Tables, drawings. *Merrill Bros.*

158. Forming Dies
Data on roller dies for forming tubes and rolled shapes. *American Roller Die*

159. Foundry Coatings
Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

160. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

161. Furnaces
16-page booklet "Proven Heat Treating Efficiency" displays complete line of furnaces. *Loftus Engineering*

162. Furnaces
High temperature furnaces for temperatures up to 2000 F. are described in bulletin. *Carl-Mayer Corp.*

163. Steel Bars, Shafting



A set of six bulletins, totaling 120 pages, deals with all types and many applications of cold drawn steel bars and shafting. Included are properties of free-machining bars, definition of shafting and factors governing its applications, carburizing and other heat treatments. Bessemer steel bars, carbon, alloy and stainless bars are included. *Union Drawn Steel Div., Republic Steel*

164. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

165. Furnaces, Heat Treating
Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

166. Furnaces, Heat Treating
Catalog on furnaces for tool room and general-purpose heat treat. *Cooley*

167. Furnaces, Rotary Hearth
Folder giving drawings, dimensions, capacity, Btu required for drawing, annealing, forging. *Gas Machinery*

168. Galvanizing
Reprint "Modern Hot-Dip Galvanizing" deals with dross formation as a cause of zinc waste. Detailed information on zinc ammonium chloride type of flux. *Hanson-Van Winkle-Munning*

169. Galvanizing
Bulletin on galvanizing furnaces and equipment. *Furnace Engineers*

170. Gear Hardening
Folder on application of induction heating to high-production hardening of gears. *Westinghouse*

171. Gold Plating
Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. Uses. *Technic, Inc.*

172. Gold Plating
Folder on salts for bright gold plating. Also lists equipment needed. *Sel-Rex*

173. Grainal Steel
6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

174. Hard Facing
12-page bulletin on hard facing electrodes indicates correct type of electrode or rod to use in about 75 common types of hard facing applications. *Alloy Rods*

175. Hardness Numbers
Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

176. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

177. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

178. Hard Surfacing
16-page bulletin gives applications, 14 case histories of Electrolizing process. *Electrolizing Corp.*

179. Heat Treat Baskets
Bulletin on wire mesh baskets for heat treating and plating. *Wiretex Mfg.*

180. Heat Treat Loader
Bulletin on equipment for loading metered quantities of parts into heat treating furnaces. *Michigan Crane and Conveyor*

181. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

182. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam*

183. Heat Treating
56-page "Heat Treating Alloy Steels". *Republic Steel*

184. Heat Treating Aluminum
Bulletin on furnaces for aging, annealing, heat treating and forging aluminum. *Morrison Eng'g. Corp.*

185. Heat Treating Aluminum
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

186. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

187. Heat Treating Furnaces
8-page bulletin illustrates 14 types of furnaces. *Lee Wilson Contracting Co.*

488. Heat Treating Stainless
84-page book on heat treating stainless steels, both martensitic and austenitic. *Republic Steel*

489. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

490. High-Temperature Alloy
New 12-page booklet on fabrication and design data for stainless 330 (35% Ni – 15% Cr) and other alloys. *Rolled Alloys*

491. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

492. High-Temperature Belts
24-page bulletin on metal conveyor belts. *Wickwire Spencer*

493. Humidity Testing
Bulletin on test units for automatically maintaining humidity conditions from 20 to 95%. *Bowser*

494. Hydraulic Presses
Bulletin 147, "Practical Facts About Hydraulic Presses", an informative guide for the user of all types and sizes of hydraulic presses. *Lake Erie Engineering Corp.*

495. Hydrogen Atmosphere
Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to 70° F. *Baker & Co.*

496. Identifying Alloys
Booklet of procedures for rapid identification of more than 125 metals and alloys. *International Nickel*

497. Illium
Data on corrosion resistance, strength and workability of Illium alloy. *Illium*

498. Impregnation of Castings
Report M-10 on impregnation costs, amortization, results. *Seal Cast Co.*

499. Induction Heating
Data folder on megacycle tube-type machines for soldering, brazing, hardening. *Sherman Industrial Electronics*

500. Induction Heating
Review of applications of 60-cycle induction heating. *Induction Heating Devices*

501. Induction Heating
40-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

502. Induction Heating
Bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

503. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

504. Induction Heating
12-page bulletin 5679 on induction hardening, brazing, annealing at 1000, 3000, and 10,000 cycles. *General Electric*

505. Industrial Furnaces
Book 127 on planning expansion, remodeling or modernization of plant. *Continental Industrial Engineers*

506. Instruments
34-page book describes 37 instruments for electrical, physical, resistance-welding, ultrasonic and other measurements. *Brush Electronics*

507. Instruments
28-page catalog No. 5000 describes instruments, control devices and related components manufactured by the company. *Minneapolis-Honeywell*

508. Insulating Brick
Bulletin on fire brick and sil-o-cel insulating brick. *Johns-Manville*

509. Laboratory Furnaces
Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

510. Leak Detector
16-page bulletin on leak detector for location and measurement of leaks in evacuated or pressure systems. *Consolidated Vacuum Corp.*

511. Liquid Carburizing
Bulletin gives case depth and hardness vs. time of carburizing; also timing chart for neutral salt baths. *Bellis*

512. Low-Carbon Stainless
New bulletin, "Melting Low-Carbon Stainless Steel", shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical*

513. Lubrication
24-page illustrated bulletin gives history of 100 years progress in cutting oils, core oils and lubricants. *Swan-Finch Oil Corp.*

514. Machining Alloy Steels
24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

515. Machining Costs
12-page "Relation of Machining Time to Material Cost". Comparative machinability costs per ton for eleven steels. *La Salle Steel*

516. Magnesium Applications
60-page book gives 54 case studies on uses. *Dow Chemical*

517. Melting
24-page book on electric furnaces for steel mills and foundries. Table of types, sizes, ratings. *American Bridge*

518. Metallograph
Bulletin on camera microscope and metallograph. *United Scientific*

519. Metallograph
20-page book on desk-type metallograph. *American Optical*

520. Metallograph
Metallograph, described in catalog E-240, furnishes four different accurate images of same sample for complete identification with bright field, dark field or polarized light. *Bausch & Lomb*

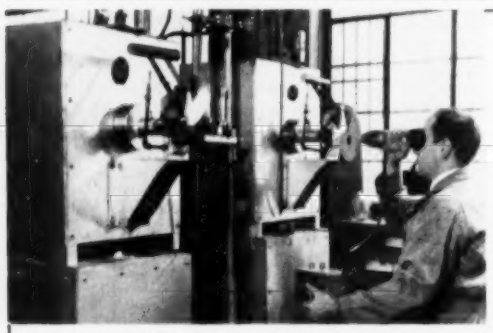
521. Metallurgical Apparatus
200-page catalog of metallurgical apparatus: cutters, grinders, mounting presses, polishers, metallographs, microscopes, cameras, testing machines, analytical apparatus, spectrographs, furnaces, accessories and supplies, and 250 recommended metallurgical books. *Buehler Ltd.*

522. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

523. Moly-Sulphide Lubricant
40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

524. Nickel Alloys
40-page book gives corrosion, physical and mechanical properties of Hastelloy alloys; 13 pages of fabrication data. *Haynes Stellite*

525. Nickel Plating
12-page reprint, "Mechanical Properties of Nickel Deposits", deals with effects of plating variables on properties. 13 charts, 3 tables, 40 micrographs. *International Nickel*



Harper GT-20-HM-30 Tubular Element Furnaces in operation at Permo, Inc., Chicago, Illinois. Max. Temp. 3000° F. (Photo courtesy of Permo)

Harper

Versatile-Economical Harper Tube Furnaces Sinter Alloy-Tips for Phonograph Needles at Permo

The two furnaces shown above are being used extensively for both research and production sintering of various precious metal tip alloys for Permo long-life phonograph needles.

Mr. W. H. Lenz, Metallurgical Director at Permo, says: "We have found them very useful, adaptable and economical for this high temperature work. The furnaces are versatile to the extent that they may be operated, if desired, with almost any kind of atmosphere including air."

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Facts about *HELI-COIL* inserts you should know

What they are

*Heli-Coil** screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: *Heli-Coil* inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with *Heli-Coil* inserts. Get better-than-original strength with no increase in screw size and no tell-tale signs of rework.

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads—then *Heli-Coil* inserts are wound into tapped holes by hand or power tools. Install in a few seconds, assure thread protection forever. Can be used in any metal wood or plastic.

No other method is so simple, effective and practical.

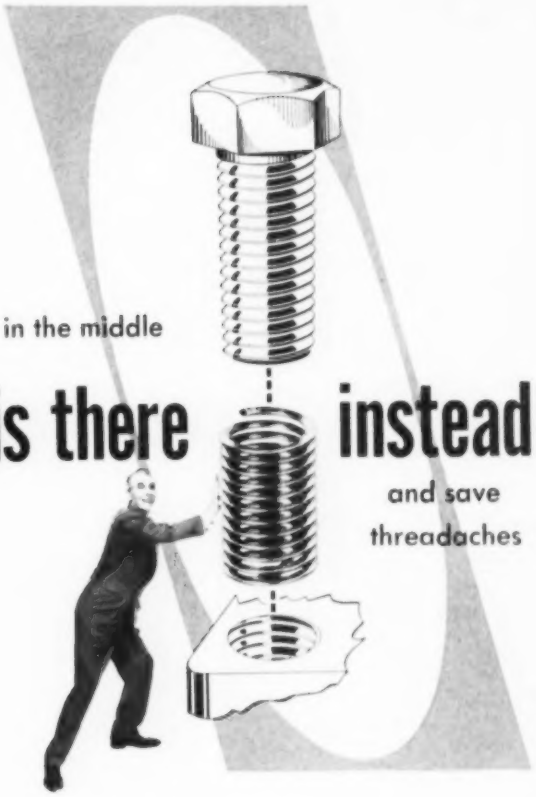
What they do for you

Heli-Coil inserts *save money* because they strengthen threads and make *fewer* smaller fastenings do the same holding job. They make *lighter* bosses and flanges practical and they *save weight* in two ways: (1) by permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. *Heli-Coil* inserts *protect* your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. *Heli-Coil* inserts improve the end product, cut rejects, salvage threading errors.

Best time to put *Heli-Coil* inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write today! Complete information and engineering data is available in the *Heli-Coil* catalog. Use Coupon!

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Approved for All Military and Industrial Uses



Don't get caught in the middle

put this there instead

and save threadaches

Sales demanding "twice the product at half the price"? Does production want "half the cost and half the time" on the production line? Where are you? Caught in the middle?

You can be a hero to both sales management *and* production management by telling them about *Heli-Coil** Screw Thread Inserts.

These precision formed inserts of stainless steel or phosphor bronze wire make vastly stronger threads in metal, plastics, and other materials. So much stronger that you can safely use smaller and fewer and shorter cap screws—thinner sections, lighter bosses. Thus costs are reduced, production simplified. And threads cannot strip, corrode or gall—they never wear out.

Learn how other designers are using *Heli-Coil* Screw Thread Inserts. Get the technical data you need to apply them to your "threadaches." Use the coupon—now!

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HELI-COIL CORPORATION

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☐ Send Free samples and Handbook No. 652, a complete design manual.

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COMPANY _____

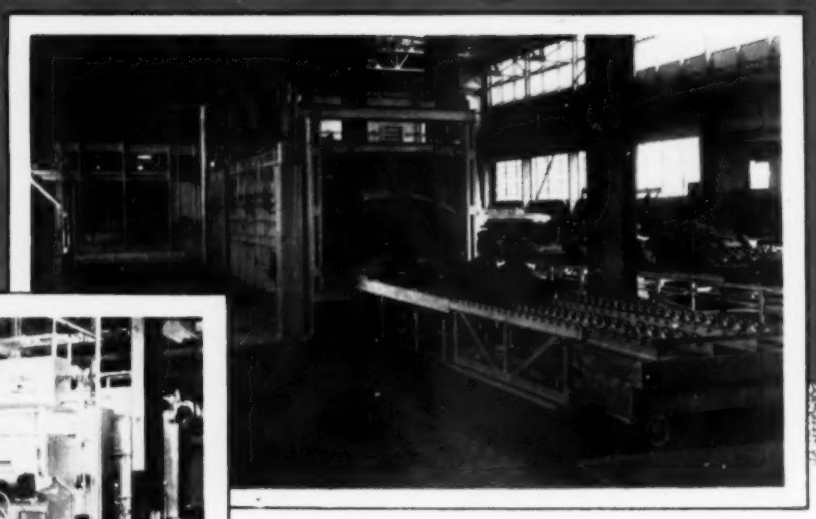
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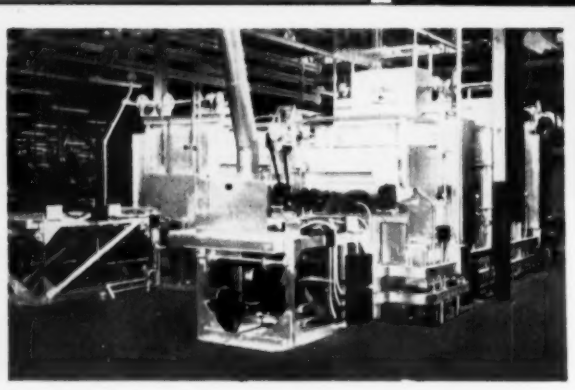
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Automatically

Automatic, continuous heat treat line for hardening, quench, and draw of steel wheels designed and built by Loftus.



Automatic, continuous heat treat line for hardening, quench, and draw of small automobile parts designed and built by Loftus.



Send today for 16 page Booklet:
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Shows many furnace types.



Loftus Continuous Heat Treat Lines offer efficient design for handling your product by tray, where the product is loaded and unloaded at one point. Direct, or atmosphere control type furnaces are engineered to render economical, automatic heat treating service. The "Pin-Point Quench" and washer is completely automatic. Construction of "in-line," "square," or rotary layout is dependent upon your individual requirements. Practical, *one operator* units can be built for loads of from 500 to 6000 pounds per hour.

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Designers and Builders of Industrial Furnaces

610 Smithfield Street, Pittsburgh 22, Pennsylvania

526. Nitrogen Atmosphere
Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

527. Nondestructive Testing
Data on equipment for inspection and sorting. *Magnetic Analysis*

528. Nonferrous Castings
20-page Catalog 53 on aluminum, magnesium and bronze castings. *Wellman Bronze & Aluminum*

529. Nonferrous Melting
Bulletin C-2 on gas-fired crucible furnaces for melting nonferrous metals. *Eclipse*

530. Nonferrous Tubing
Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

531. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

532. Periodic Chart
Latest periodic chart of the elements. Green and black, 11 by 14 in., official 1952 data. *General Electric*

533. Pickling
80-page book "Efficient Pickling" covers all variables of process. Charts and tables. *American Chemical*

534. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

535. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

536. Plating Solutions
Bulletin 12 on electric heating of pickling and plating solutions. *Pyrosil*

537. Plating Wastes
8-page reprint on ion exchange treatment of plating wastes. Cost comparison. *Permutit Co.*

538. Pots
Bulletin N-1 on pressed steel pots for lead, salt, oil tempering and metal melting. *Eclipse Fuel Engineering*

539. Powder Metallurgy
32-page handbook gives 24 case histories of parts designed or redesigned for powder metal production. Cost comparisons; definitions of terms and list of standards. *New Jersey Zinc*

540. Precision Forgings
Data folder on small metal parts forged to within a few thousandths. *Utica Drop Forge*

541. Precision Metalworking
16-page bulletin on services for melting and casting small ingots, forging and precision rolling, slitting, straightening and heat treating to close tolerances. *Precision Mfg. Services, Hamilton Watch Co.*

542. Press Applications
20-page bulletin shows variety of press applications. *Hydraulic Press Mfg.*

543. Punches and Dies
36-page Catalog 152A on punches, dies and accessories. *Ward Machinery*

544. Pyrometer Supplies
Buyers' Guide for pyrometer supplies, No. 100-4. *Minneapolis-Honeywell*

545. Pyrometer Supplies
56-page Users' Manual and Buyers' Guide. Specifications, prices, thermocouple calibration data. *Bristol Co.*

546. Pyrometers
Data sheets on high resistance indicating pyrometers. Also controls and resistance thermometers. *West Instr.*

547. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

548. Quenching
Data sheet on mixer for agitation of quenching liquids. *Chemineer*

549. Quenching
"Handbook on Quenching" gives complete information. *E. F. Houghton*

550. Radiography
12-page bulletin on X-ray inspection. *Industrial X-Ray, Inc.*

551. Reamer Selector
Pocket-size selector lists 143 hole sizes which can be reamed. *Larallee & Ide*

552. Recorders and Controllers
40-page Catalog ND44(1) on indicating recorders and controllers. *Leeds & Northrup*

553. Refractories
20-page booklet gives technical information on super refractories. *Refractories Div., Carborundum Co.*

554. Resistance Testing
Bulletin 100 on production tester for measuring electrical resistance. *Rubicon*

555. Rocket Nozzles
Data Sheet 522 on four materials of promise for rocket nozzles. *Norton Co.*

556. Roll Formed Shapes
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

(Continued on p. 32-A)

STABILIZE ALLOY STEELS
... Stabilize alloy steels by complete change of austenite to martensite

TOUGHEN METALS
... Increase toughness, hardness and life of perishable tools up to 400%

NORMALIZE CASTINGS
... Normalize magnesium, aluminum, cast-iron castings by "quick-ageing."



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chilling!

The remarkable results in stabilizing, toughening and normalizing metals effected by Sub-Zeroing make the Sub-Zero freezer an essential part of every modern heat treating department.

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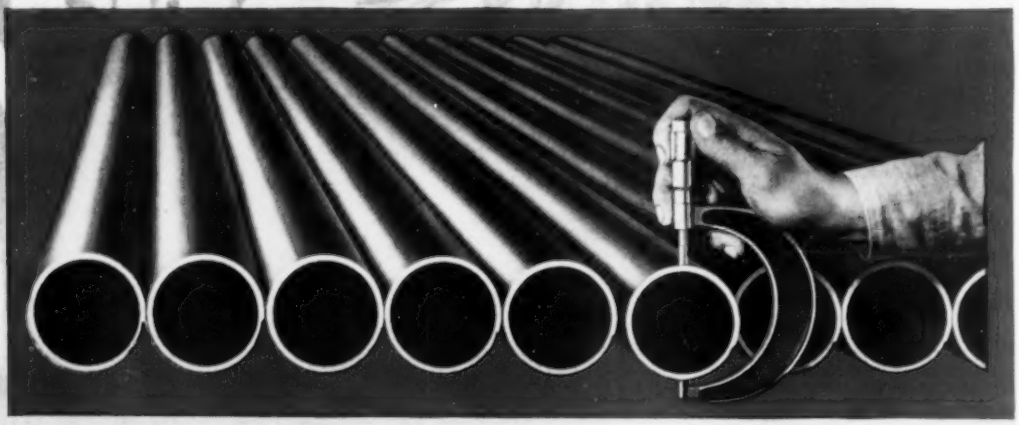
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Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
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(Continued from p. 31)

557. Salt Bath Control
Data sheet 5.2-5 describes instrumentation for temperature control of salt baths in heat treatment of high speed steel. *Minneapolis-Honeywell*

558. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

559. Salt Baths
75-page manual on salt baths for case hardening and heat treating. *DuPont*

560. Salt Baths
28-page book deals with heat treatment, carburizing, bath maintenance, safety precautions. *American Cyanamid*

561. Saws
Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

562. Screw Thread Inserts
16-page book of design data and specifications on screw thread bushings of helically coiled wire, for aluminum, magnesium, iron, steel, plastics or wood. Extensive tabular data and installation guide are included. *Heli-Coil Corp.*

563. Shearing
16-page catalog on pivoted-blade shears for cutting metal up to 1.25 in. thick. *Cleveland Crane & Engineering*

564. Shot Blasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

565. Shot Peening
24-page book gives 21 applications of shot peening, 37 references. *Metal Improvement Co.*

566. Silicon Bronze
Article on silicon bronze from "Lavingot Technical Journal". *Lavin*

567. Silver Brazing
10-page technical bulletin on brazing preforms. Specifications for 13 types of joints. *Lucas-Milhaupt*

568. Silver Brazing
Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes. *Handy & Harman*

569. Slitters
Illustrated Slitter Book gives information on merits of different types and sizes of slitters and accessories. Economics of slitter operation. *Yoder Co.*

570. Soldering Aluminum
6-page folder on use of a noncorrosive flux for soldering aluminum. Data on joint strength and ductility. *Insulation and Wires, Inc.*

571. Soldering Aluminum
Article on techniques and materials for soldering aluminum. *Reynolds Metals*

572. Soldering Irons
Folder on electric soldering irons, other soldering equipment. *Insulation & Wires, Inc.*

573. Sonic Thickness Tester
Measurement of wall thickness from one side by sonic method. *Branson*

574. Spark Testing
20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

575. Specifications Index
28-page cross index lists copper alloy specifications of nine different Government agencies. *American Brass*

576. Spun-End Tube
32-page brochure on applications of spun end tube in copper, brass and aluminum; 19 cases. *Wolverine Tube*

577. Stainless Fabrication
133-page book covers welding, riveting, soldering, joint design, machining, forming, annealing, pickling, finishing of stainless steels. *U. S. Steel*

578. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings, specialties. *Star Stainless Screw*

579. Stainless Steel
20-page book on uses of stainless steels. *Electro Metallurgical*

580. Stainless Steel
Bulletin gives examples of five types of stainless steel castings. *Sivyer*

581. Stainless Steel
Bulletin shows plates, forgings, sheets, tank heads, flanges. *G. O. Carlson*

582. Stainless Steel
Slide chart. Set top at a certain fabricating operation, bottom shows rating of each standard grade. On reverse side, heat treating and corrosion data are given. *Carpenter Steel*

583. Stainless Steel
32-page book on corrosion resistance of stainless steels. 18 tables on tests in acid, neutral and alkaline solutions. *International Nickel*

584. Stainless Tubing
6-page reprint "Tips on Stainless for Aircraft Hydraulics". Design and fabrication. *Superior Tube*

585. Stainless Tubing
28-page book on corrosion, uses and fabrication of stainless steel tubing. *Steel and Tubes Div., Republic*

586. Steel 52100
Data sheet on high-purity 5210 made by vacuum melting. *Metals*

587. Steel Plate
Slide chart gives plate weigh various widths, thicknesses. *Lu*

588. Steel Plate
32-page catalog 1243 on stee for carburizing, heat treatin welding. Many uses illustrated. *Holliday*

589. Steel Tubing
12-page bulletin on electric steel tube. *Wolverine Tube*

590. Steel Tubing
48-page Handbook F-3 on fabr and forging steel tubing. B shaping, cutting and joining ope described. *Ohio Seamless Tube*

591. Stereomicroscopes
20-page brochure on microsco three-dimensional magnification 45 diameters. *Bausch & Lomb*

592. Strain Gages
Article on fatigue life of SR-4 gages, in Testing Topics. *Be Lima-Hamilton*

593. Stress Relief of Tita
April "Review" gives data on temperature combinations for relief of titanium. *Rem-Cru*

594. Subzero Freezer
8-page folder on portable 110-volt a.c., operating to —180 shrink fitting, hardening, sta and testing. *Webber Appliance*

595. Subzero Tests
62-page bulletin on equipme low-temperature tests. *Bowser nical Refrigeration*

596. Subzero Treatment
12-page bulletin on subzero tre of tool steel and increase in t resulting. *Sub-Zero Products*

597. Super High Speed S
Folder on molybdenum, 8% high speed steel for use at sp to 25% greater than with o high speed steel. Heat trea protective coatings and uses. *Sterling*

598. Surface Temperatur
Pyrocon bulletin on hand-hel mocouple-type instrument for r ing and indicating surface te tures at exact locations. *Illinoi ing Labs.*

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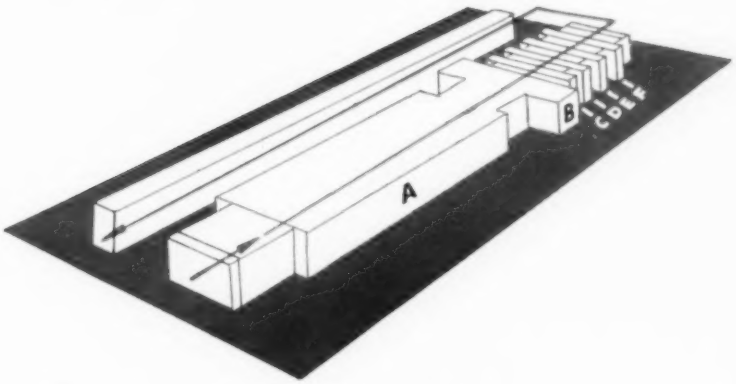
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Heat Treat Furnace Layout

by *Holcroft*... 2nd of a Series



A Annealing furnace
B Hot salt quench
C Wash
D Acid bath
E Wash
F Oil dip

Volume Production Castings Annealed, Descaled, Desanded

This "U-type" furnace layout by Holcroft ties right into the production line of a large automotive plant.

The unit anneals, descales and desands 10,000 pounds of castings each hour. After annealing, the stock is dipped in a salt quench, rinsed in water, bathed in acid, water-washed again, and dipped into a soluble oil to prevent rust. A return conveyor automatically brings the trays back to the loading point.

Unusual layouts like this present no particular problem for Holcroft. After all, it's an inherent part of the job to be completely responsible for the work—from the time it is to be heat treated to the time it's ready for finishing operations. It's the type of work Holcroft does well. Holcroft & Company, 6545 Epworth, Detroit 10, Michigan.

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ing and heating furnaces. *Diamond Power Specialty*

600. Temperature Control
36-page bulletin P 1245 on new electronic instruments for recording and indicating variables. *Bristol Co.*

601. Tempering
Reprint of article on controlled atmosphere tempering. *Ipsen*

602. Tempilstiks
"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

603. Test Specimens
Common metals and alloys mounted and identified. Photomicrographs, analyses, hardness data for comparison or teaching. *Adolph I. Buehler*

604. Testing
Bulletin on test units to combine temperature range from +185 to —100° F., relative humidity from 20 to 95%, and altitude simulation from atmospheric to 80,000 ft. *Bowser*

605. Testing
Bulletin on mechanical and nondestructive testing and on certification in accordance with procedure set up by the American Standards Association. *American Standards Testing Bureau*

606. Testing Equipment
64-page illustrated catalog lists more than 115 testing and measuring devices for laboratory and production line use. *General Electric*

607. Testing Machines
32-page catalog on hydraulic testing machines. 10 models described; also accessories. *Riehle*

608. Textured Stainless
Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

609. Thermocouple Data
42-page Bulletin TC-9 on thermocouples, radiation detectors, resistance bulbs, accessories. *Wheelco*

610. Titanium
30-page data book on properties of commercially pure and alloy titanium, melting, forging and rolling. 16 charts and micros; 4 hardness conversion curves for titanium. *Republic Steel*

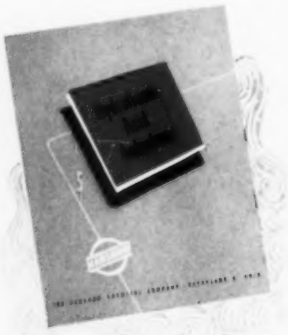
611. Tool Steel Failures
124-page book, "Tool Steel Trouble Shooter", analyzes 107 tool failures and assigns causes as among tool design faults, tool steel faults, improper heat treatment, mechanical and operational factors. *Bethlehem Steel*

612. Tool Steel Heat Treat
Bulletin 1147EE on electric furnace for heat treatment of high speed tool steel. *Hevi Duty*

613. Tool Steel Selector
Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

614. Tool Steels
Full information on uses, compositions and heat treatment of carbon and carbon-vanadium tool steels. *Vanadium-Alloys Steel Co.*

615. Hydrofluoric Acid
40-page book on hydrofluoric acid anhydrous deals with physical



properties, materials of construction, types of construction, handling, storage, sampling and analysis. *Harshaw Chemical*

616. Transfer Machines
Bulletin on fully automatic transfer machines that combine double-end machining and cutting to accurate length. *Motch & Merryweather*

617. Tubing Failures
46-page book on tube life in high-pressure high-temperature applications. Results of a great number of investigations of failures. *Babcock & Wilcox*

618. Tungsten Alloy
8-page technical information bulletin on tungsten-base alloy. Mechanical and corrosion properties; joining, machining, uses. *P. R. Mallory & Co.*

619. Universal Machine
Bulletin 118 on machine for turning, grinding, milling, drilling and other operations. *Newage*

620. Vacuum Calculator
Slide rule for quick calculation of data necessary in vacuum engineering and processing — for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. *F. J. Stokes Machine*

621. Vacuum Pumps
24-page Bulletin V51 on high-vacuum pumps and accessories. *Kinney Mfg.*

622. Valves
50-page booklet on valves for the process industries. *Gas Machinery*

623. Welding Alloy Steel
44-page Data Book 4D covers all types of welding of nickel alloy steels. *International Nickel*

624. Welding Electrodes
Bulletin on electrode selection for welding stainless and alloy steels. *Arcos*

625. Welding Rods
6-page bulletin on bronze welding rods. Table gives ASTM, AWS and Government specifications. *Titan Metal*

626. Welding Steel
12-page booklet guides users of low-alloy, low-hydrogen electrodes. *Arcos*

627. Weldments
16-page bulletin illustrates a variety of steel weldments. *Struthers Wells*

628. Weld-Rod Dehydrating
Bulletin on low-hydrogen electrode stabilizer. Specifications of equipment for dehydrating mineral shielding on low-hydrogen electrodes. *Archer*

629. Wire Mesh Belts
140-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

630. Wire Straightening
Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Medart Co.*

631. X-Ray Diffraction
Analytical applications of X-ray diffraction using direct measurement techniques. *X-Ray Dept., G.E.*

632. X-Ray Supplies
50-page catalog of industrial X-ray supplies and accessories. *Westinghouse*

August, 1953

325	349	373	397	421	445	469	493	517	541	565	589	613
326	350	374	398	422	446	470	494	518	542	566	590	614
327	351	375	399	423	447	471	495	519	543	567	591	615
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331	355	379	403	427	451	475	499	523	547	571	595	619
332	356	380	404	428	452	476	500	524	548	572	596	620
333	357	381	405	429	453	477	501	525	549	573	597	621
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339	363	387	411	435	459	483	507	531	555	579	603	627
340	364	388	412	436	460	484	508	532	556	580	604	628
341	365	389	413	437	461	485	509	533	557	581	605	629
342	366	390	414	438	462	486	510	534	558	582	606	630
343	367	391	415	439	463	487	511	535	559	583	607	631
344	368	392	416	440	464	488	512	536	560	584	608	632
345	369	393	417	441	465	489	513	537	561	585	609	
346	370	394	418	442	466	490	514	538	562	586	610	
347	371	395	419	443	467	491	515	539	563	587	611	
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LANDING THE F-86 SABRE JET ON TWO FINGERS... FINGERS FORGED BY UTICA

When the North American F-86 Sabre Jet swoops in for a landing, two steel fingers control the landing shock. Like fingers in a dike, the pins meter hydraulic fluid through a small orifice to cushion the landing. Varied contour of the pin serves to vary resistance developed.

These pins are UTICA forgings, and point up an unusual development story. Under conventional forging methods, they would be expensive to produce because of immense machining required. Forging is practical only because UTICA has a "short-cut" production method for upsetting far greater than the standard three diameters.

They start by upsetting 15⅓ diameters

Each pin starts as a ¾" diameter, 21½" bar of SAE 4130. In one of UTICA's electrical upsetting machines 11½" is upset—*more than half the bar and, actually, 15⅓ diameters!* The bulb on the end is forged to rough shape, then machined to final dimensions. The UTICA forged part replaced the original part which was welded and required extensive machining. The new full-forged part has greater strength and requires much less machining. We are very proud the Cleveland Pneumatic Tool Co. picked UTICA Drop Forge for this important defense job.

New forging techniques ready for tomorrow

In defense production, UTICA has helped pioneer new techniques in forging both the old and the "new" hard-to-handle metals. Perhaps we can serve you—*tomorrow* . . . with forgings for advanced new products that will be tomorrow's leaders.

Our new booklet "File Facts on Precision Forgings" outlines UTICA'S methods and facilities, now totally engaged in defense production, but ultimately generally available. Send for your free copy.



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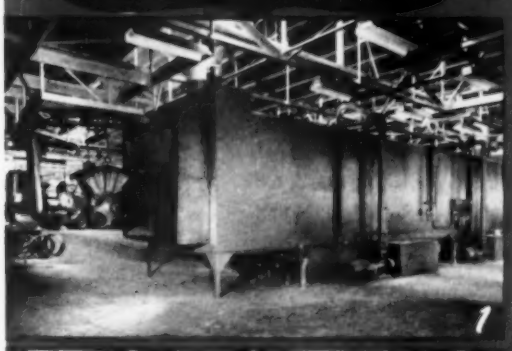
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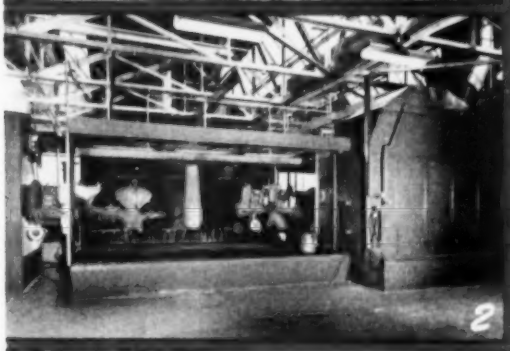


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A FINISHED TRACTOR *every 5 minutes!*

Tractor finishing at the J. I. Case tractor plant, Rock Island, Ill., has been doubled and quality of finish raised to a new high with this modern finishing system designed, built and installed by Despatch. Housed in a new, well lighted building the system is giving Case tractors a rich, durable baked on finish in the familiar Case Flambeau Red. The operation includes washing, painting and finish baking accomplished as the tractors move on a 600-ft. continuous monorail conveyor. It's all done in a fraction of the time formerly required on another system, and at reduced labor and material costs.

1 After loading the conveyor enters 3-stage washer where tractor gets a 160° F. phosphate wash, cold water mist bath, and 180° F. hot water rinse.

2 Tractors are spray painted as they move through staggered water wash spray booths, each 20 feet long. Paint is heated to 170° F. —eliminates need for thinner and allows closer spraying to cut down overspray. Each unit receives one coat which represents 2 gallons of paint.

3 A lasting, weather resistant finish is baked on at a temperature of 225° F. in this 96-ft. oven heated by steam from the Case central steam plant. As the tractor emerges from the oven, tires coming to the area via another conveyor line are mounted, and other parts are added to complete the unit. Tractors are taken off the conveyor in the unload zone at the extreme left and driven away under their own power.

LET DESPATCH MODERNIZE YOUR FINISHING OPERATIONS

Now is the time to replace your obsolete finishing system with a modern Despatch system. Increased production, higher quality and lower costs will result. Despatch engineers are ready to analyze your problem and plan a system best suited to fit your particular needs.

Write, wire or call Dept. P today for further details.

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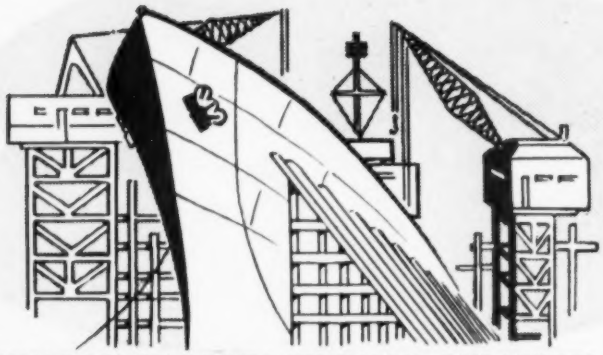
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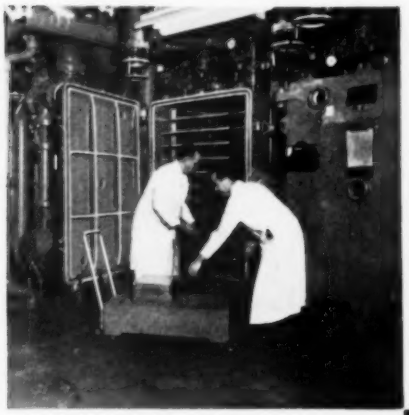
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Stokes equipment is used for the shelf-drying of procaine penicillin under vacuum at the New Brunswick, N. J. plant of E. R. Squibb & Sons.





One of the uses for the complete custom-built installation of Stokes vacuum freeze-drying equipment in Pitman-Moore Company's new million-dollar plant at Indianapolis, Ind. is to produce gamma globulin to combat poliomyelitis. One of the steps is drying the material from its frozen state. Operators are shown removing trays of gamma globulin from Stokes freeze-dryers at temperatures of 40° below zero F.



Diesel locomotive armature being removed, after impregnation, from Stokes high vacuum impregnating tank in the San Bernardino, Calif., plant of Atchison, Topeka & Santa Fe Railway. Electric motors for the Santa Fe's "Chief" and "Super Chief" develop such excessive heat that ordinary insulation would swell or burst, causing the rotors to "freeze" in the mounting. By impregnating these rotors with protective resins under high vacuum in Stokes impregnators, each turn of wire is held rigidly in place and the motors operate without interruption.

IN VACUUM ENGINEERING... NOTHING SUCCEEDS LIKE SUCCESS!

Stokes' success in the application of Vacuum Engineering to industry is based on the practical experience of many years in the study and practice of vacuum processing.

The first commercial production of blood plasma to save human lives was initiated by Stokes engineers on Stokes vacuum processing equipment. Hog cholera serum to protect and increase the world's meat supply is largely produced on Stokes equipment by vacuum processing methods. More recently, Stokes freeze-drying equipment has been used to produce gamma globulin, the first real ray of hope in the fight against paralytic poliomyelitis.

New markets for low-cost metals and plastics which simulate more costly pieces have been created through the use of Stokes vacuum metallizing equipment. Electric and electronic equipment is now processed in Stokes vacuum impregnation units to prepare it for the heavy loads and exacting requirements of modern electric and electronic practice.

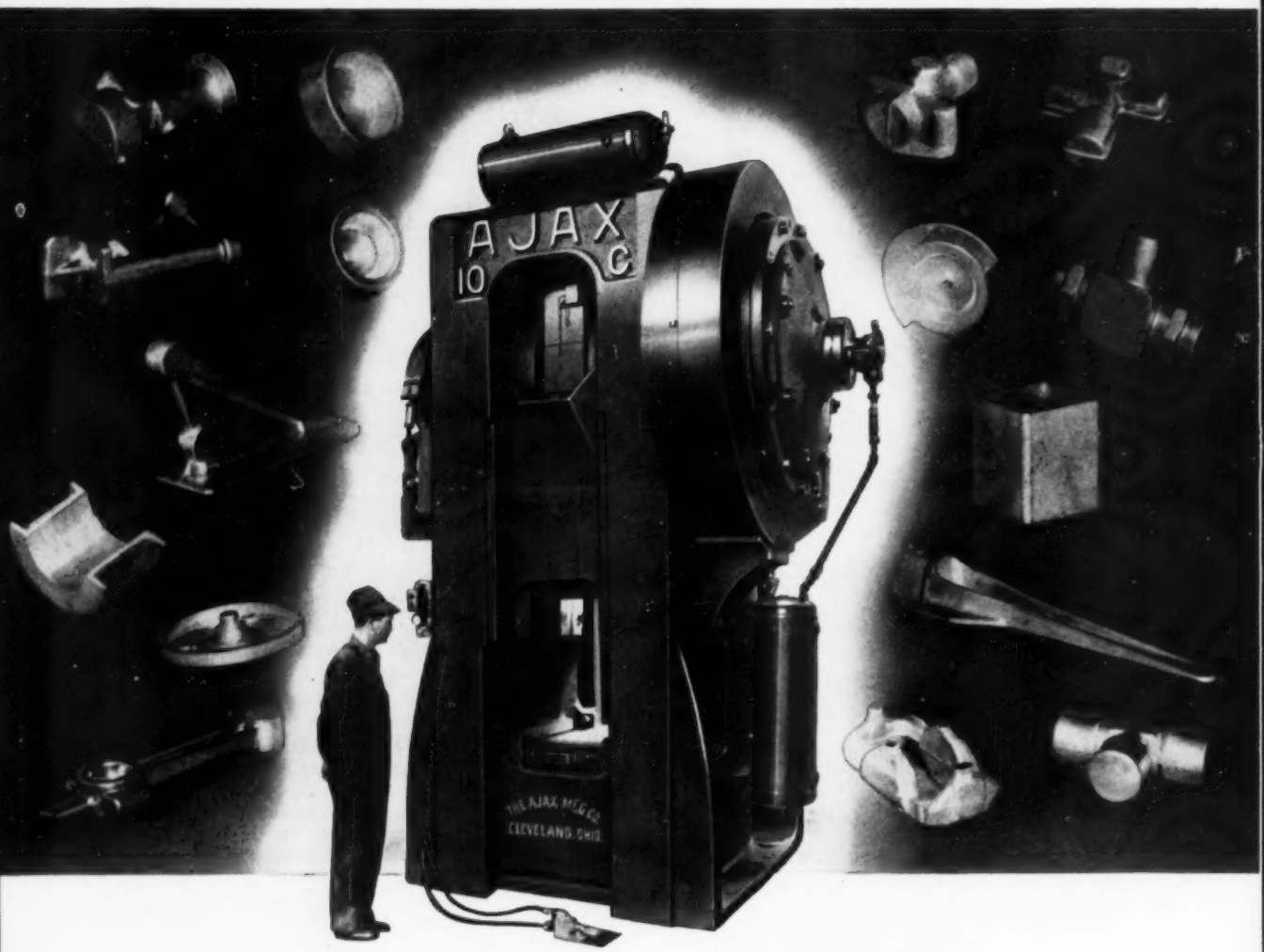
Stokes is FIRST in Vacuum Engineering by virtue of fifty years of experience in the manufacture of practical production equipment. You are invited, without obligation, to consult with Stokes Vacuum Engineers on any phase of Vacuum Engineering — drying, freeze-drying, metallizing, impregnation or vacuum furnace processing—which can be applied to your business.

F. J. Stokes Machine Company, Philadelphia 20, Pa.

STOKES

STOKES MAKES: High Vacuum Equipment, Vacuum Pumps and Gages / Industrial Tabletting, Powder Metal and Plastics Molding Presses / Pharmaceutical Equipment

AJAX *High Speed* Forging Presses



MORE ACCURATE FORGINGS at HIGH PRODUCTION SPEEDS

AJAX PRESSES are built in a wide range of sizes

FIVE HUNDRED TO EIGHT THOUSAND TONS CAPACITY

WRITE FOR BULLETIN 75B

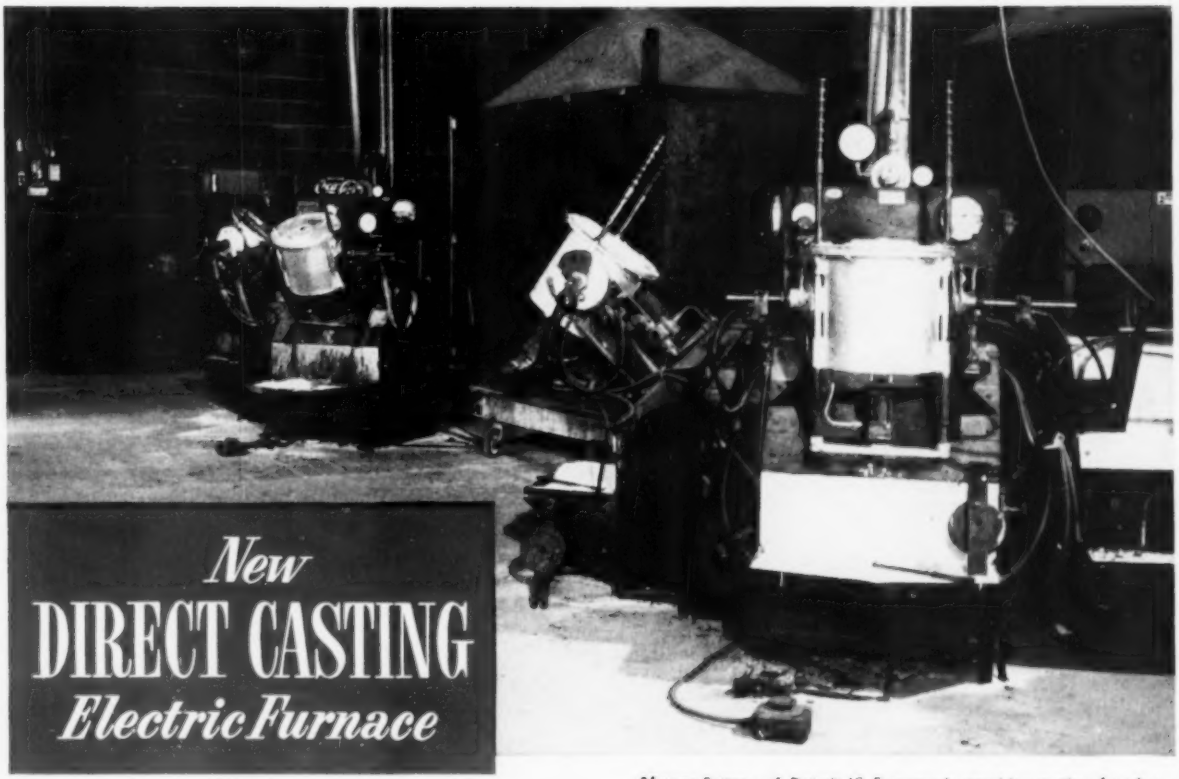
THE **AJAX** MANUFACTURING COMPANY

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DEWART BUILDING NEW LONDON, CONN.

FOREIGN AGENTS IN PRINCIPAL COUNTRIES OF THE WORLD



New DIRECT CASTING *Electric Furnace*

Above: Battery of Detroit IC Furnaces in precision casting foundry.
Below: Workman ready to invert furnace for casting into attached investment.



Detroit Electric Furnace Produces 6-lb. Investment Castings In 7-13 Minutes *All Day Long*

This new Detroit Electric Furnace is designed for better, faster investment casting. There's no pouring, ladling or handling of molten metal. You get fast melting *plus* direct furnace-to-mold casting in one easy operation. Just charge and melt—when ready for casting, invert the furnace and pour directly into attached investment. Detach the mold and you're ready to repeat the cycle—in 7 to 13 minutes.*

Fast, controlled melting by indirect arc holds alloy variation and carbon pick-up to a minimum. Low power consumption, high utilization of heat promotes operating economy. Uniform results through melt after melt mean fewer rejected castings, greater over-all efficiency.

Investigate the advantages of this new high-production furnace for investment casting. Write today for details on the Type IC Detroit Electric Furnace.

*Typical Melting-Casting Data for Type IC-12KW, 10-lb. Detroit Electric Furnace.

Metal	Weight Charge	Over-all Melt-Cast Cycle	Power Consumption
Stainless Steel	6 lb.	13 Min.	.364 KW/lb.
Stellite	5¾ lb.	12 Min.	.340 KW/lb.
Gray Iron	6 lb.	12 Min.	.333 KW/lb.
Copper	6 lb.	8½ Min.	.203 KW/lb.
Yellow Brass	6 lb.	7½ Min.	.179 KW/lb.

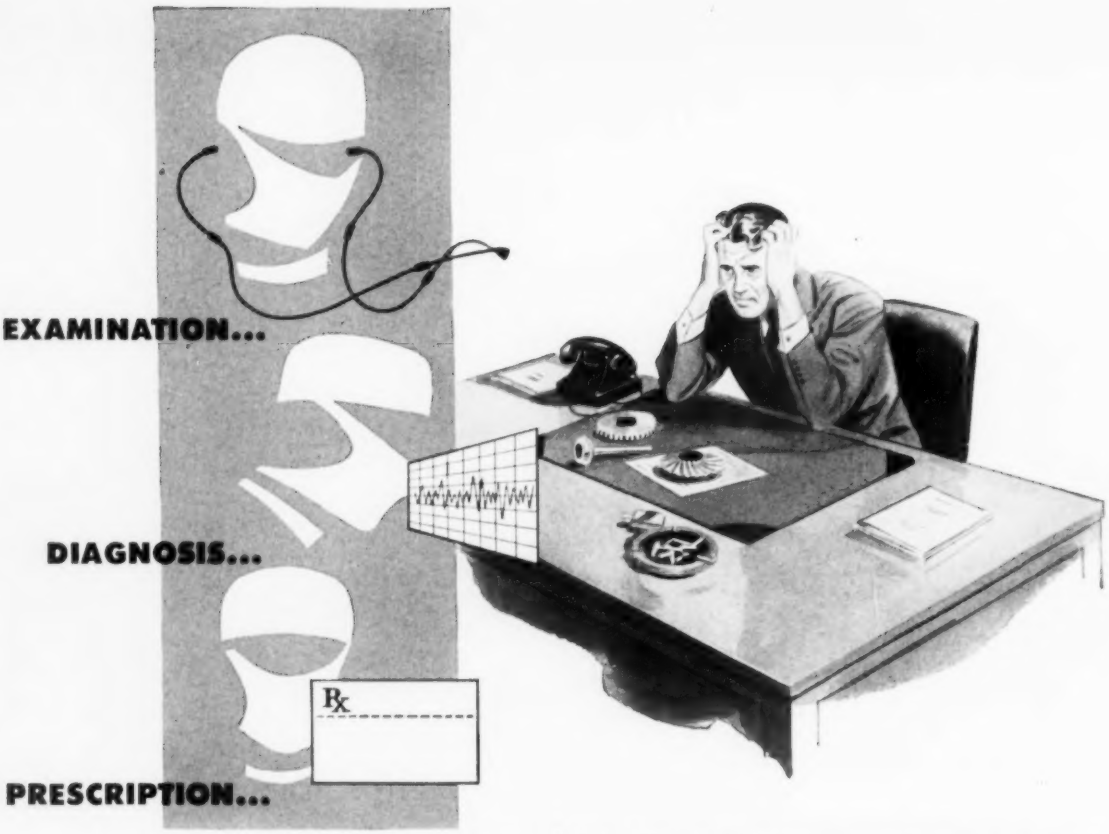


Faster Heats
Better Metal ROCKING action does it

DETROIT ELECTRIC FURNACE DIVISION

Kuhlman Electric Company • Bay City, Michigan

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Business "HEADACHES" relieved with Republic

3-DIMENSION METALLURGICAL SERVICE

First comes the examination of your steel "headache". . . machinability, or tool life, or heat treatment, or surface finish, or excessive rejects, or any of the problems that you face in production. Here's where you meet the Republic Field Metallurgist.

He discusses the symptoms with the other two members of Republic 3-Dimension Metallurgical Service . . . the Republic Mill Metallurgist and the Republic Laboratory Metallurgist. They look at your symptoms from all three angles . . . the best Republic Alloy Steel to do the job properly, to work efficiently in your plant to keep your costs down.

Then . . . back comes the Republic Field Metallurgist with recommendations that will give you the quality your product requires at the speed you need to show a profit.

Got a steel headache? Tell your Republic Sales Office representative about it . . . he'll have a Republic Field Metallurgist in your plant promptly.



. . . combines the extensive experience and coordinated abilities of Republic's *Field, Mill* and *Laboratory* Metallurgists with the knowledge and skills of your own engineers. It has helped guide users of Alloy Steels in countless industries to the correct steel and its most efficient usage. IT CAN DO THE SAME FOR YOU.

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Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC STEEL

Republic ALLOY STEELS

NEW PANGBORN BLASTMASTER BARREL

cleans wide variety of materials

FASTER—CHEAPER—BETTER!



Exclusive Blastmaster construction features:



WORK CONVEYOR will not clog. Hardened steel chain with special metal slats designed so no aperture will pinch work. Drives through V-Belt to Spur Gear-Reducer mounted directly on work conveyor shaft—simple—effective—safe.



WORK CONVEYOR TAKE-UP is on bottom shaft where weight of conveyor makes it easier to adjust.



AUTOMATIC THROW-OUT TORQUE ARM protection disengages the barrel drive in case of jams. Works in both loading and unloading directions.



ABRASIVE-TIGHT DOOR. Woven wire mesh construction backed with vulcanized rubber. Rolls up compactly when door is opened. Slides on rollers in mechanized labyrinth. Always protected against abrasive action and tumbling castings by heavy rubber curtain.

READ over the wide variety of materials that Pangborn's new Blastmaster ROTOBLAST® Barrel cleans—and the firms that have bought the barrel. Then think of how this versatile machine can help you get more efficient, more rapid, and more economical blast cleaning in *your* shop! Remember—the Blastmaster features famous Pangborn ROTOBLAST, that saves you money these five ways:

SAVES LABOR with push-button operation
SAVES SPACE because machines are compact
SAVES TIME by cleaning more loads per day
SAVES POWER since no compressor is needed
SAVES TOOLS because all scale is removed

If *you're* interested in better, faster, cheaper blast cleaning, you owe it to yourself to find out more about the Pangborn Blastmaster Barrel. It's available in 4 sizes—3, 6, 12, and 18 cu. ft. capacity. For more details about the Blastmaster and other equipment in the famous Pangborn line, write for Bulletin No. 223 (Blastmaster Barrel) or No. 214 (all ROTOBLAST equipment). Address: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Maryland.

OVER 28,000 PANGBORN MACHINES SERVING INDUSTRY

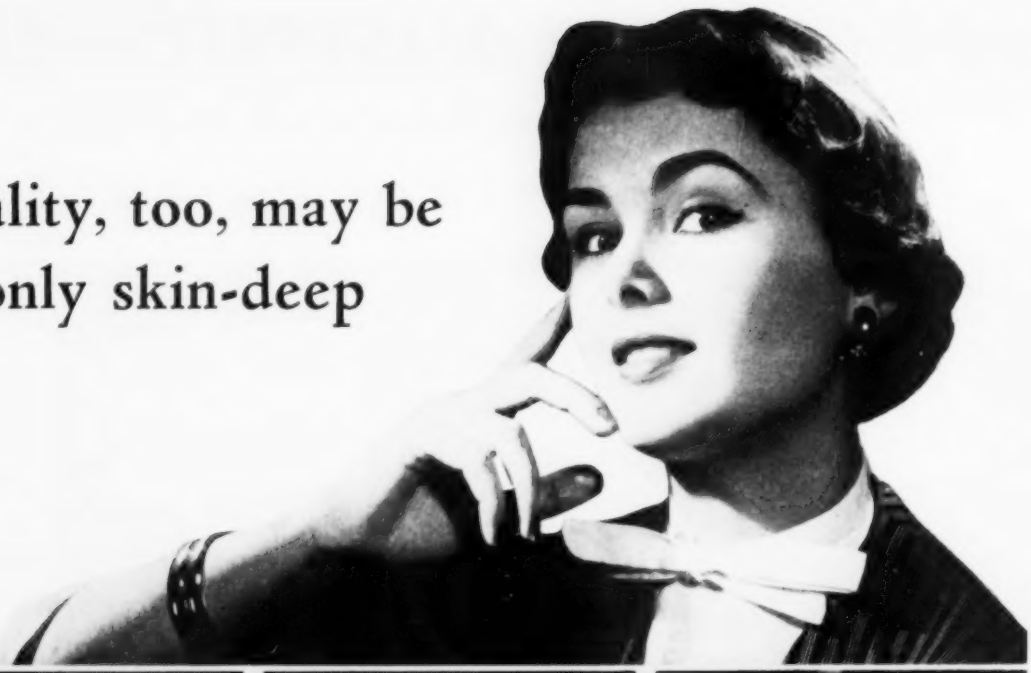
Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment

Pangborn

BLAST CLEANS CHEAPER

with the right equipment for every job

Quality, too, may be only skin-deep

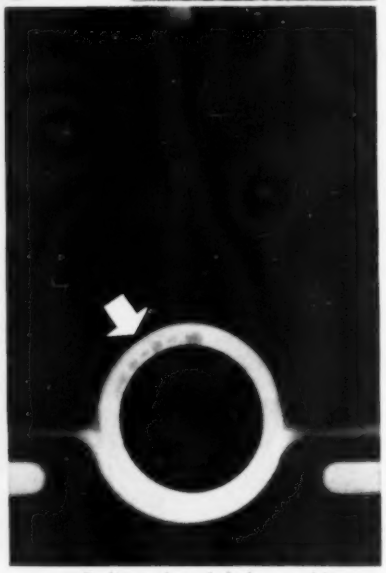




1 This apparently sound casting comes from the foundry ready for subsequent machining.



2 Machining uncovers blowholes at critical point—necessitating rejection or repair.



3 Radiograph made before machining would have revealed blowholes, saved time and money.

For fast, non-destructive inspection, use General Electric Industrial X-Ray

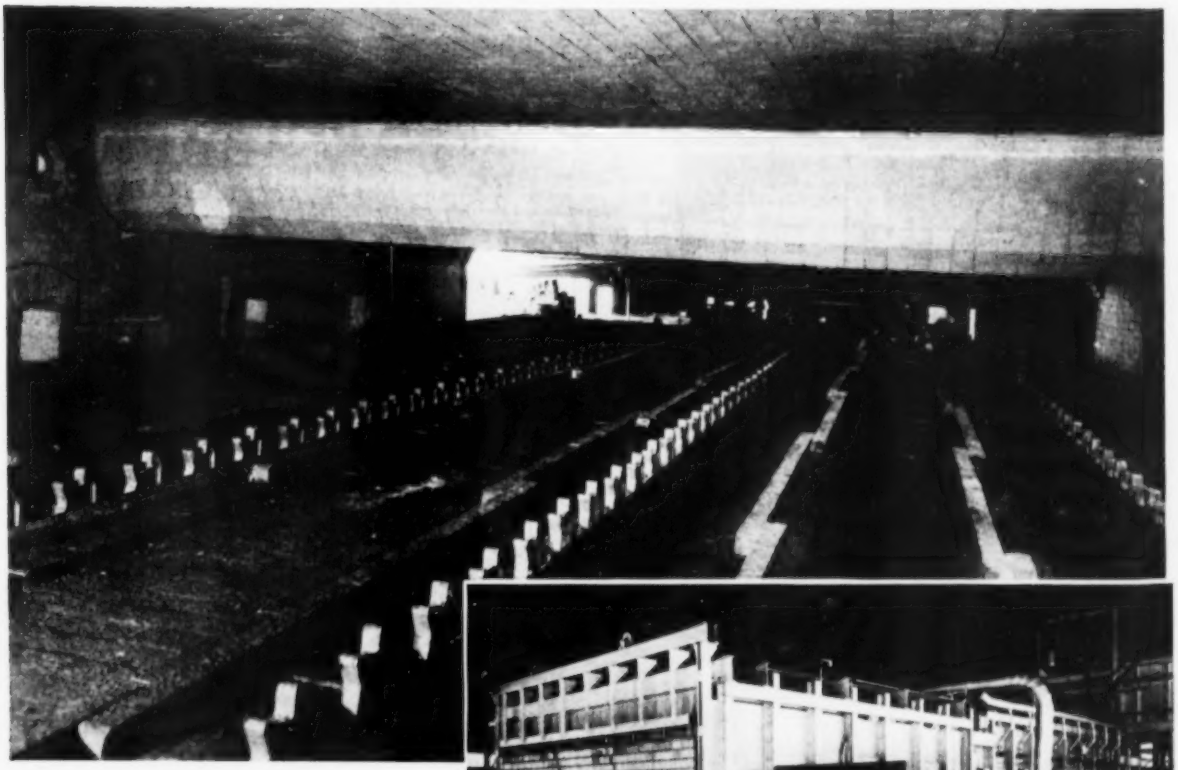
Whether you're buying or selling castings, x-ray inspection is a high-speed, low-cost method of insuring unvarying quality. Hidden defects in job lots or on production lines are detected prior to expensive finishing operations.

The above illustrations show why so many leading industries today rely on x-ray for non-destructive inspection. In many plants, x-ray is also used as a development tool — to disclose where savings can be made, designs improved, new techniques developed.

Chances are, there's a place for industrial x-ray in your business. We will be glad to appraise your needs. Or, if you have a specific problem, GE has probably handled a parallel situation. You can benefit from this previous experience by writing X-Ray Department, General Electric Co., Milwaukee 1, Wis., Rm. AS-8.

You can put your confidence in —

GENERAL ELECTRIC



▲ Looking toward the charging end of this 52-ft long furnace designed by R-S Products Corporation. The CARBOFRAX skids are staggered to provide for expansion. Toothlike conveyor chains move the pipe through the furnace.

Outside view of the same furnace. ▶

No repairs in 3 years...

but there's even more to this skid rail story

This furnace is used to anneal large cast-iron pipe. It was put in operation by Glamorgan Pipe & Foundry Company of Lynchburg, Va. in the Spring of 1947.

Week after week the CARBOFRAX® silicon carbide skid rails did their job without any attention whatsoever — *for three full years*. Then, less than half the rails were replaced. Another partial replacement followed two years later. And today, some of the original rails are still in use after six years. But this is just half the story!

These refractory skids also prevented the usual troubles experienced when water cooling is used. That is, the non-cooled CARBOFRAX rails gave a hot, point-of-contact surface so that the pipes heated evenly and were free from cold spots. Moreover, CARBOFRAX skids cost much less than alloy pipe.

CARBOFRAX skid rails can provide similar benefits in most reheating furnaces. If you have not investigated, it may pay to do so. Start by getting our complimentary skid rail booklet. Address: Dept. C-83, Refractories Div., The Carborundum Company, Perth Amboy, N. J.

CARBORUNDUM

Registered Trade Mark



Yes, let's take the brush holders and rigging in this H-VW-M generator... they're fully insulated for longer life. Look, too, at the pigtail bar which eliminates current passage through springs and fingers. And the special copper graphite brushes—they give you optimum commutator efficiency. The molded "equaload" shunts distribute the brush load equally, minimizing selective action. And that's only the beginning...

All these exclusive improvements are the results of over eighty years of constant development...a continuing policy summed up in H-VW-M Platemanship—your working guarantee of the best that industry has to offer, not only in low-voltage generators, but in every phase of plating and polishing.

8336

For technical information on low-voltage generators ask for Bulletin G-102.

Your H-VW-M combination—of the most modern testing and development laboratory—of over 80 years experience in every phase of plating and polishing—of a complete equipment, process and supply line for every need.

HANSON-VAN WINKLE-MUNNING CO., MATAWAN, N. J.

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SALES OFFICES: ANDERSON • BALTIMORE • BOSTON CHICAGO • CLEVELAND • DAYTON • DETROIT • GRAND RAPIDS • LOS ANGELES • LOUISVILLE • MATAWAN MILWAUKEE • NEW YORK • PHILADELPHIA • PITTSBURGH ROCHESTER • SPRINGFIELD (MASS.) • STRATFORD (CONN.) UTICA • WALLINGFORD (CONN.)

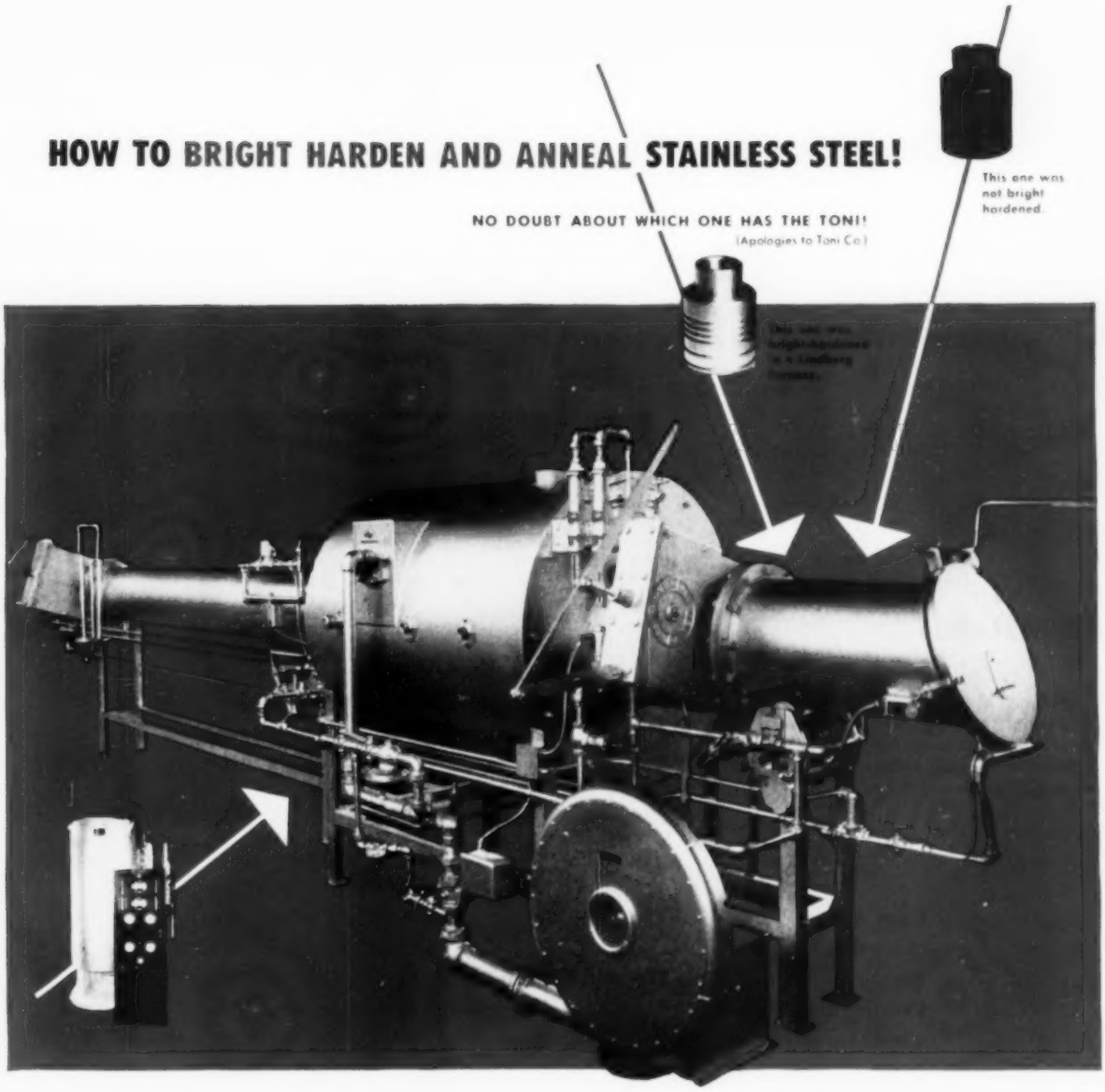
H-VW-M

INDUSTRY'S WORKSHOP FOR THE FINEST IN PLATING AND POLISHING PROCESSES • EQUIPMENT • SUPPLIES

HOW TO BRIGHT HARDEN AND ANNEAL STAINLESS STEEL!

NO DOUBT ABOUT WHICH ONE HAS THE TONI!

(Apologies to Toni Co.)



If your production requirements call for the bright heat treating of stainless steel, completely free from oxidation and discoloration . . you'll want to know more about this amazing Lindberg Stainless Steel Heat Treating Furnace, many of which have been in successful use throughout the country for 4 years. They are *specifically designed* for the heat treatment of stainless steels and other high alloy materials.

This process eliminates the need for operations such as pickling, sandblasting, and machining . . which are not only costly and time-consuming, but also often disturb the delicate balance of the alloying elements on the surface of the metal.

Lindberg Stainless Steel Heat Treating Furnaces are built with purging chambers at *both* the charging and the discharging ends. This eliminates the chance of work chamber atmosphere becoming contaminated by either oxygen or water vapor . . which will oxidize stainless steel.

These furnaces use protective atmosphere supplied by Lindberg HYAM Hydryzing Generators. Atmosphere consists of dissociated ammonia (75% hydrogen and 25% nitrogen . . dew point, minus 60°F).

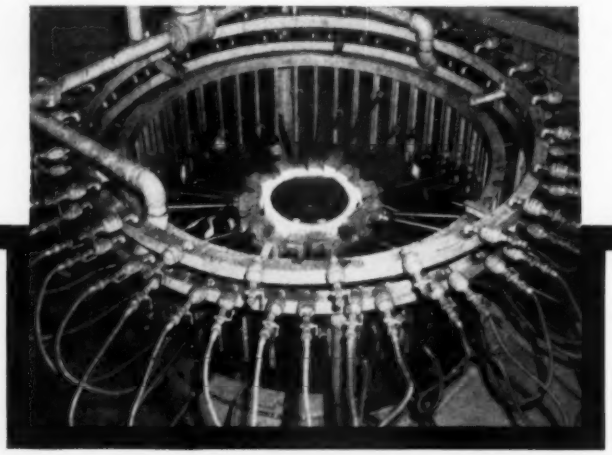
Your "Lindberg man" will be glad to tell you more . . call him.

LINDBERG FURNACES

Lindberg Engineering Company • 2448 W. Hubbard Street • Chicago 12, Illinois

case-hardening of gears with efficient GAS equipment

cuts processing time 75%



The process efficiency of GAS for heat-treating is emphasized by the flexible equipment employed by *Wesley Steel Treating Company, Milwaukee*, to case-harden gears and sprockets up to 60" diameter.

Case depth and hardness are completely and precisely controlled in this efficient GAS heat-treating installation. Because the unit is so simply adjusted for applying the productive flames of GAS to gears of varying diameters, this modern GAS equipment is flexible enough for a wide range of heat-treating applications.

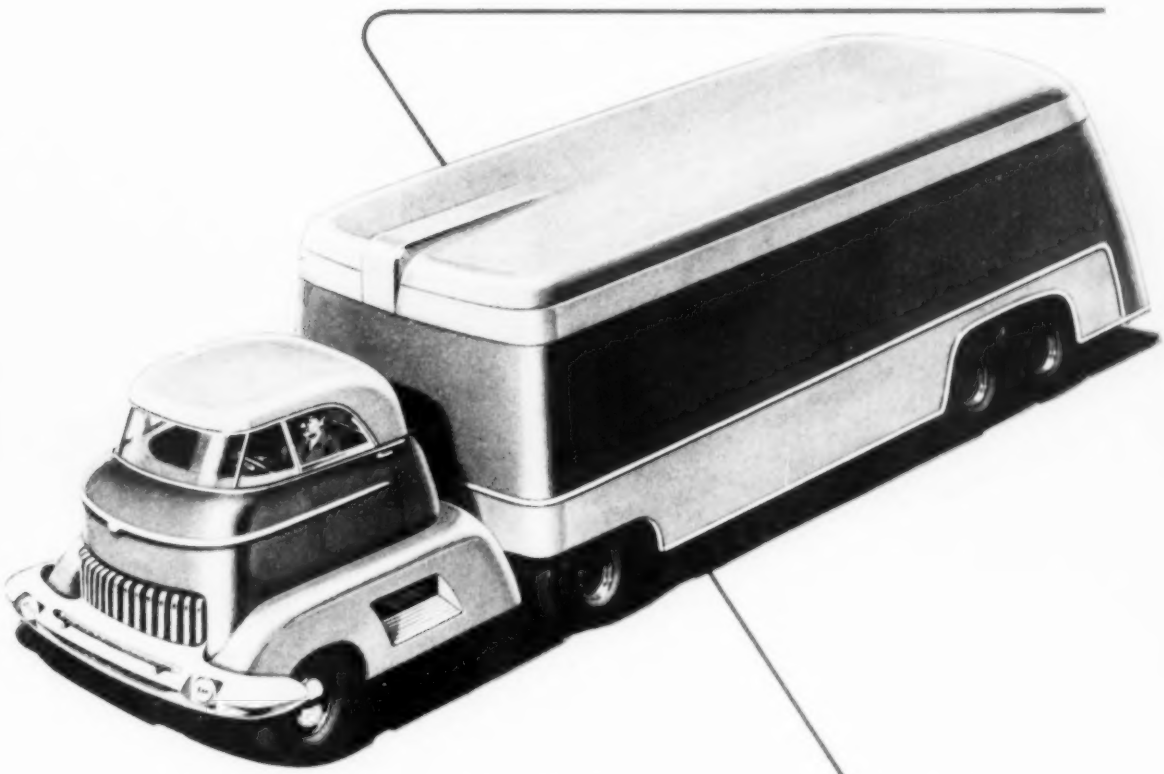
The *process efficiency* of GAS for heat-treating is demonstrated by the important time reduction from 1 hour with previous equipment to 15 minutes with this modern GAS installation. Furthermore, the complete controllability of the heating and quenching cycle in this unit has reduced the rejects in gears and sprockets of every size.

MORE AND MORE
THE TREND IS TO GAS
FOR INDUSTRIAL PROCESSING

There are many important reasons why GAS is the ideal fuel for production-line processing. You'll find it worthwhile to evaluate the advantages of GAS versus other processing methods.

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Specify **N-A-X** HIGH-TENSILE STEEL for **Lighter Weight, Longer Life and Operating Economy**



N-A-X HIGH-TENSILE, having 50% greater strength than mild carbon steel, permits the use of thinner sections—resulting in lighter weight of products. It is a low-alloy steel—possessing much greater resistance to corrosion than mild carbon steel with either painted or unpainted surfaces. Combined with this characteristic, it has high fatigue and toughness values at normal and sub-zero temperatures, and the abrasion resistance of a medium high carbon steel—resulting in longer life of products.

N-A-X HIGH-TENSILE, with its higher physical properties, can be readily formed into the most difficult stamped shapes, and its response to welding, by any method, is excellent. Due to its inherently fine grain and higher hardness, it can be ground and polished to a high degree of lustre at lower cost than can mild carbon steel.

Savings in vehicle weight, with no loss in structural strength, increase the payload ratio and give greater operating economy when you make it a point to specify N-A-X HIGH-TENSILE steel for your highway equipment.

MAKE A TON OF SHEET STEEL GO FARTHER Specify— N-A-X HIGH-TENSILE STEEL ... And "MAKE YOUR PRODUCT LAST LONGER"

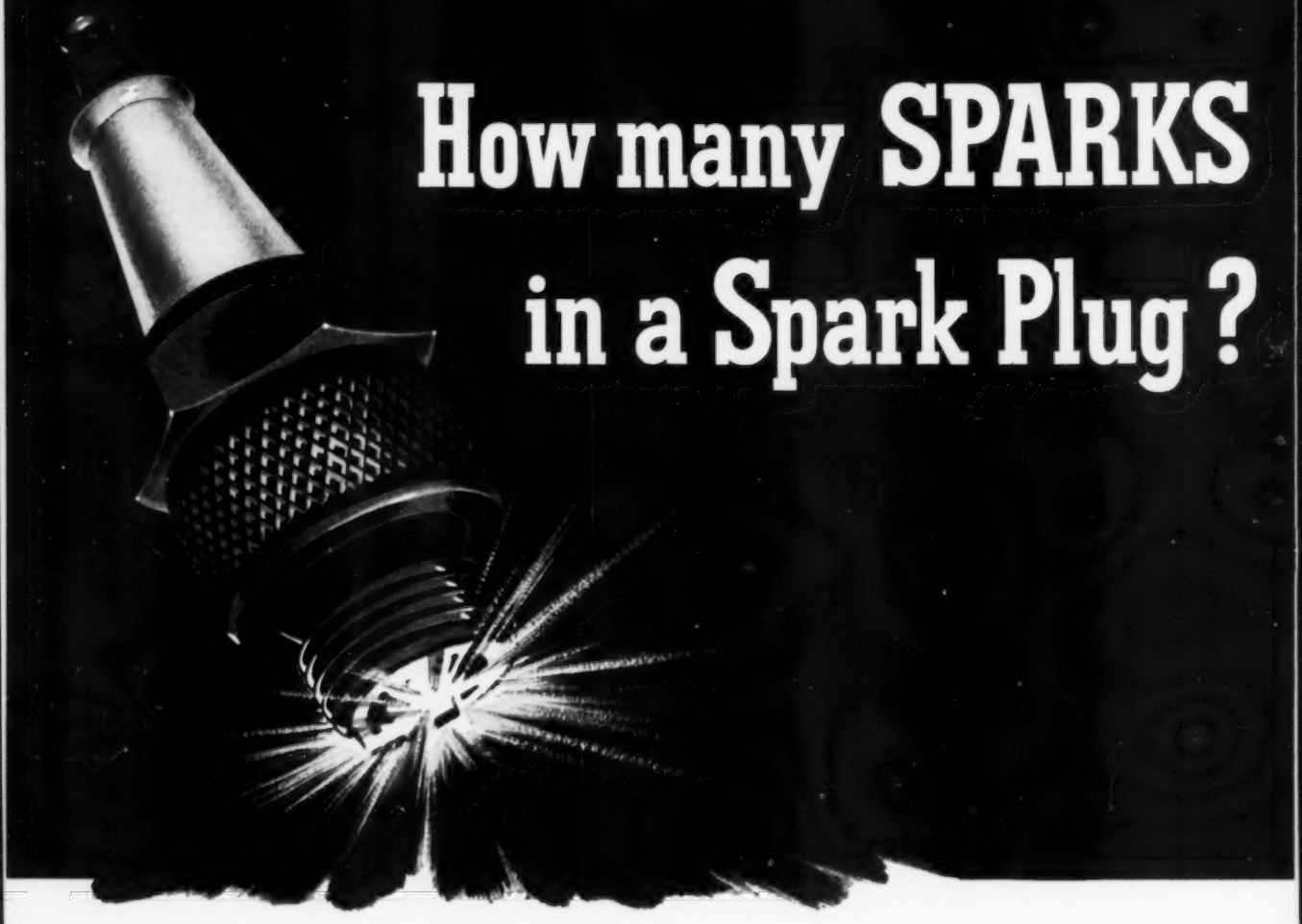
GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division — Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

KEEP YOUR SCRAP MOVING TO YOUR DEALER

How many SPARKS in a Spark Plug?



Surprising, the confidence that people have in spark plugs. No one stops to question how many "sparks" they're good for, because long-life performance has come to be taken for granted. Yet, when you get right down to it, you'll find good reasons for this complete consumer confidence. And, from a "sparking" point of view, perhaps the most important is the almost universal use of special Hoskins alloys for the vital electrode wires.

Producing the wire that sparks your car to power is a tough and tricky business. It requires special care in the selection of raw materials. Special melting and production techniques. Plus extremely close control over alloy composition and uniformity of quality throughout the entire manufacturing process.

Yet that's exactly the kind of alloy that Hoskins is qualified to produce best. For, among the other quality-controlled alloys developed and manufactured by Hoskins are: Alloy 717—for facing engine valves; Alloy 785—for brazing belts; Alloy 502—for countless heat resistant mechanical applications. Then, too, there are the Chromel-Alumel thermocouple alloys . . . guaranteed to register true temperature-EMF values within specified close limits. And, of course, Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.



Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.



Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.



Chromel-Alumel thermocouple alloys accurately measure exhaust temperatures of jet aircraft engines.

Chromel® NICKEL CHROMIUM WIRE

HOSKINS

MANUFACTURING COMPANY

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New development

in rare-earth research

Lan-cer-amp ≠10 is the fruition of continuing research in the plant and laboratories of American Metallurgical Products Company. It consists of vacuum-produced rare-earth metals combined with a revolutionary new catalytic agent and sealed in a heavy steel bomb which sinks to the bottom of the ladle before it disintegrates, thus providing better mechanical dispersion in the molten metal. Lan-cer-amp ≠10 requires no changes in melting practice. It is the least expensive method, currently in existence, of adding rare-earth to steel. Full production has been attained and orders are being accepted for reasonable delivery.

American Metallurgical Products Company

3600 Forbes Street · Pittsburgh 13, Pa.

meet the "Sandman"



Yep! . . . there really is a sandman! Sivyer's sandman, however, is a symbol of vigilance . . . for he uses special equipment and a broad practical knowledge to test sand for specific moulding jobs. Dimensional accuracy, the finish, even the internal flawlessness of a casting may depend on his tests for proper bond, grain size, and permeability. The unique skill of our sand laboratories is another Sivyer service that insures casting quality and integrity for you.

wake up to better steel castings

A letter or a wire will get you prompt action and details on any problem or service involving high alloy and specification steel castings. Get acquainted with the famous Sivyer for better castings.

SIVYER

SPECIALISTS IN HIGH ALLOY AND SPECIFICATION STEEL CASTINGS

SIVYER STEEL CASTING COMPANY • MILWAUKEE CHICAGO

WHAT DOES FIRTH STERLING OFFER YOU?

(ANSWER NUMBER 2)

ONE SOURCE FOR ALL TOOLING NEEDS

THE *RIGHT* STEEL *OR* CARBIDE . . . THE *EXACT* METALLURGICAL COMBINATION NEEDED TO DO YOUR JOB BEST . . . FROM A SINGLE MANUFACTURING SOURCE

The next time you have a difficult tooling problem we invite you to call in a Firth Sterling man.

He may be called a "tooling specialist" or a "sales engineer" . . . but anyhow he's just a fellow who understands the *cutting*, *shaping* and *forming* of metals like nobody's business. He *may* be a graduate engineer, or he may have learned the hard way on a milling cutter, draw bench or press, but he *knows* the score.

He can give you an unbiased recommendation . . . because he has approximately 100 different grades of Firth Sterling high speed steels, and tool and die steels to choose from *and* a dozen grades of tungsten carbide in everything from die nibs to a virtually unlimited variety of standard and special carbide cutting tools and tips.

All this is backed by 64 years of leadership in the development and production of special purpose steels, and 21 years of pioneering in carbide and "powder metallurgy" applications.

It makes sense, that a company which engages in *all* phases of tooling metallurgy will serve your interests best.

Remember, Firth Sterling *is* a single, dependable source for complete shop tooling.

Firth Sterling Stands for Metallurgical Achievement—Past, Present, Future

1-2

SWALLOW WITH CONFIDENCE!



Never give it a "second thought" . . . your capsules are *pure*. Because the producers of pharmaceuticals have already given purity *their* "first" thought, and enlisted the resources of metallurgy to assure it!

You see, capsules are made by dipping the "teeth" of a rake-like metal mold into hot liquid gelatin. A thin coating adheres, dries and hardens on emergence, and the resultant half-capsule is stripped off by mechanical fingers.

Now liquid gelatin is very *corrosive* to metal, and the scraping action of the strippers is *abrasive*. Corrosion and abrasion may cause contamination. So mold teeth of Firth Sterling *Chromium Carbide* provide maximum protection against these twin threats to purity.

Why? Because Chromium Carbide is *10 times* as resistant to corrosion as 18.8 stainless and many times more resistant to abrasion! Add the qualities of extreme resistance to oxidation at high temperatures, lower weight and higher coefficient of expansion to other carbides, capacity to take a hard, bright finish . . . and you have a metal to conjure with!

Such are the attributes of Chromium Carbide. What uses can *you* make of it?

For metallurgical specialties, needed in an "atomic age", depend on Firth Sterling advanced research, development and production. *Firth Sterling stands for metallurgical achievement . . . past, present, future.*

A-264

Firth Sterling

INC.

GENERAL OFFICES: 3113 FORBES ST., PITTSBURGH 30, PA.

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PRODUCTS OF FIRTH STERLING METALLURGY

High Speed Steels
Tool & Die Steels
Stainless Specialties
High Temperature Alloys
Sintered Tungsten Carbides
Firth Heavy Metal
Chromium Carbides
High Temperature Cermets

What a record!

...6 Color-coded Temperature Records on one ROUND Chart



THE MULTI-RECORD DYNALOG*

What convenience! What economy! You can record up to 6 related temperatures on a single *circular* chart with this Foxboro Multi-Record Dynalog. Not only saves panel space, but simplifies comparison of records. There's only one pen arm — yet all 6 records appear in different, distinctive colors. Bulletin 427-1 tells the complete story. (Bulletin 444 describes the Multi-Record *Pneumatic* Receiver). Write for your copy. The Foxboro Company, 528 Neponset Ave., Foxboro, Mass., U.S.A.

*Reg. U. S. Pat. Off

Check these outstanding features

- High speed recording — only 6 seconds between prints for quick detection of process variations.
- Uses convenient, low cost circular charts.
- Each record line has its own distinctive, non-smudging color.
- No battery, no standardizing, no galvanometer, no slide wire.
- Unmatched accuracy, lowest maintenance, greatest convenience.
- Available with alarms or on-off control.
- Thermocouple or resistance-bulb types.

FOXBORO REG. U. S. PAT. OFF. — MULTI-RECORD DYNALOG

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

Three types of tool steel solve most hot-work problems

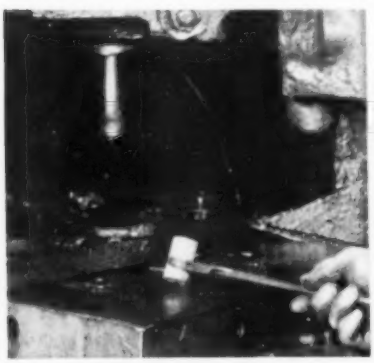
Hot-work tool steels which contain large amounts of either tungsten or molybdenum have high "red-hardness." In other words, they withstand very high operating temperatures without softening.

Although these steels have excellent wear-resistance, they cannot be subjected to drastic water-cooling while in operation because this results in excessive "heat-checking." Caused by repeated thermal stress, this condition shortens their service life. The 8½-pct-molybdenum type (our Hot-Work 8) is better in this respect than the 9-pct-tungsten type (our 57 Hot-Work).

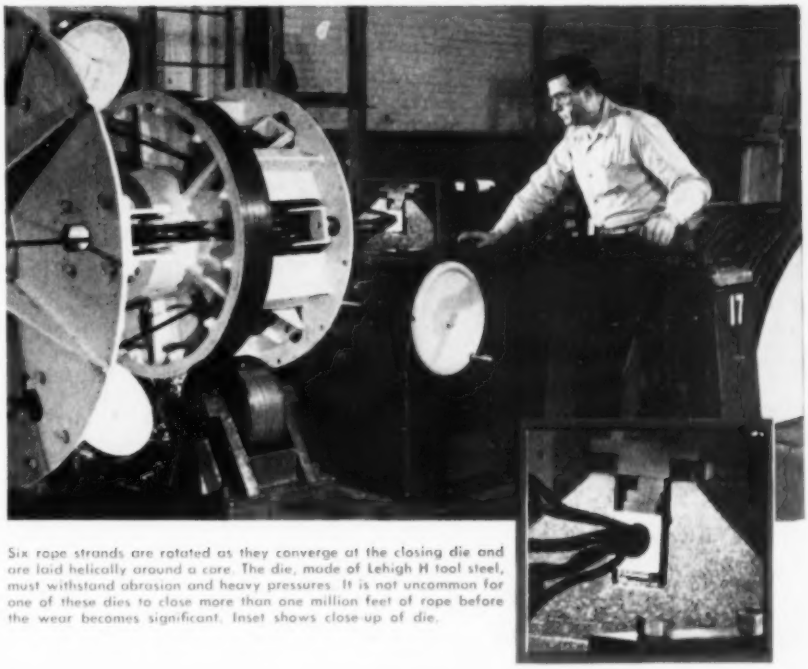
One way to prevent excessive temperature build-up, in repetitive operations where water-cooling is not used, is to provide duplicate tools which can be used alternately in the operation. This arrangement makes possible a longer cooling time between operations than if only one tool is used.

Whenever the nature of the hot-work operation is such that water-cooling of the tool is practical, it is often best to use one of the 5-pct-chromium types of hot-work steel—such as our chrome-moly-tungsten (Cr-Mo-W) and chrome-moly-vanadium (Cr-Mo-V) grades. The cooling prevents loss of hardness due to high temperature.

Although they have lower red-hardness, the 5-pct-chromium grades are good choices for tools and dies which involve both shock and hot-metal contact.



Operated in a 400-ton press, this punch is made of Bethlehem Cr-Mo-W tool steel. It extrudes steel slugs heated to 1950 F in the making of rock bits.



Six rope strands are rotated as they converge at the closing die and are laid helically around a core. The die, made of Lehigh H tool steel, must withstand abrasion and heavy pressures. It is not uncommon for one of these dies to close more than one million feet of rope before the wear becomes significant. Inset shows close-up of die.

Wire rope "closed" by long-wearing dies of LEHIGH H tool steel

One of the vital steps in the making of wire rope is the "closing" operation which arranges the rope strands compactly in a helical position around a core of either hemp or steel wire.

Closing dies are subject to considerable abrasion by the rotating strands as they converge at the die and pass through, at the same time being laid into accurate position. Lehigh H is ideal for this application because its high-carbon, high-chromium composition gives it extreme long-wearing properties. When the dies eventually become worn, they are usually refinished for use in closing rope of a larger diameter.

Made in two pieces, closing dies are machined to accurate size, heat-treated to a hardness of about Rockwell C-61; then they are ground and polished to avoid damage to the wearing surfaces.

Because of its air-hardening characteristics, Lehigh H is subject to only the minimum amount of distortion during heat-treatment—an important feature wherever accuracy is essential.



BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid sharp-cornered keyways

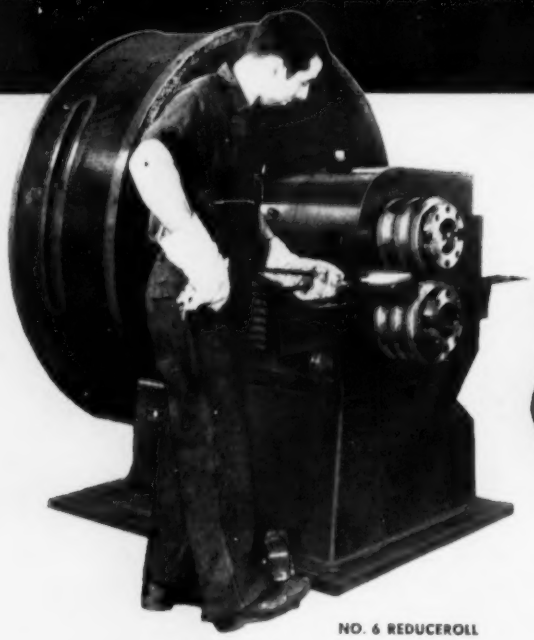
Keyways with sharp corners are the cause of many shaft failures. Fundamentally, this type of breakage is a fatigue-failure due to excessive stress-concentration at the sharp corners.

The cure for failures of this kind is to make keyways of half-round design and use a round key in the assembly.

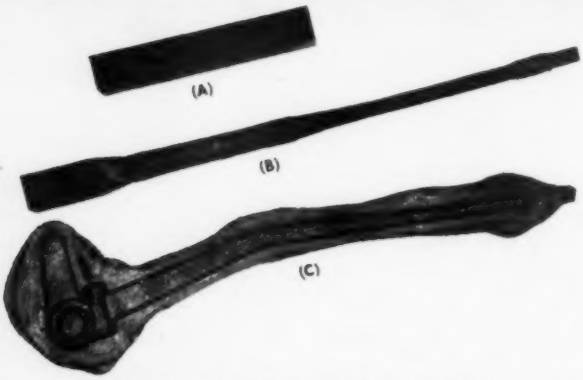
Of course, the fact that stresses are low often prevents the failure of shafts with square keyways; and so this design continues to be used. But that does not alter the fact that a square keyway on a shaft is a basic design fault.

SAVED BY REDUCEROLLING . . .

ONE MAN . . . ONE HEAT . . . ONE POUND of STEEL per FORGING!



NO. 6 REDUCEROLL



At Canada Foundries and Forgings Ltd., Welland, Ontario, the clutch pedal forging illustrated above, was *formerly* forged as follows: Stock was heated and upset in a 3" upsetter, then reheated and finish-forged in a 2500 lb. hammer. These operations required a crew of five men.

Now, by substituting a No. 6 REDUCEROLL for the upsetter, the blank is REDUCEROLLED and finish-forged on the same heat. This method requires only four men, and it saves one pound of steel per forging!

Stock (A) measures 1½ inches square by 9¾ inches long, weighs 6.24 lbs. REDUCEROLLED blank (B) ready for forging. Finished forging (C) forged on the original heat. Note small amount of flash.

REDUCEROLLING gives these advantages:

1. Increases production
2. Does not require skilled labor
3. Increases forging die life
4. Saves expensive material
5. Low-cost, quickly interchangeable rolls

NATIONAL MACHINERY COMPANY

TIFFIN, OHIO — SINCE 1874

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

Hartford Detroit Chicago

The Brazing is Practically Free!

...when you combine it with salt bath carburizing or hardening

Any material that can be brazed at all can be brazed in an Ajax Electric Salt Bath Furnace—much faster, better and usually at lower cost. But that's only part of the story!

Where a steel assembly for brazing also requires carburizing or hardening, the entire job can be done in a single heating operation so that brazing is practically free. Note examples on this page.

The "secret" lies in brazing with brass during the carburizing operation. This money-saving method is possible only with a salt bath furnace, thanks to its greater heating speed—so fast that no dezincification of the brazing metal occurs. Moreover, the steel assembly is brazed and carburized below 1700° F. instead of at 2050° F. as required for copper brazing. Thus, distortion and grain growth are greatly reduced and furnace operating costs are less. Conclusive tests prove that brass-brazed joints are fully as strong as those of copper.

For straight brazing employing copper, silver or aluminum, the Ajax furnace offers from 4- to 6-times faster heating cycles. Amazingly accurate temperature control minimizes distortion. Selective heating is easy. Scaling or decarburization are avoided and floor space requirements are only a fraction of those required with any other production brazing system.

Write *for Ajax Bulletin #72 and Reprint #124*

Bring *production batches of your materials to the Ajax Metallurgical Service labs for on-the-job demonstrations of Ajax efficiency.*

AJAX ELECTRIC COMPANY, INC.
910 Frankford Avenue **Philadelphia 23, Pa.**

Associated companies: Ajax Electric Furnace Corp.; Ajax Electrothermic Corp.; Ajax Engineering Corp.

A 51% Saving!



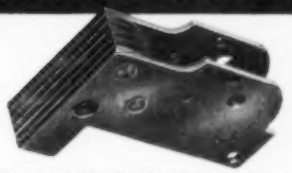
Ajax combined carburizing and brass-brazing reduced rejects 50%, effected savings of 51% and improved the quality of this wrench jaw. Steel jaw insert is brazed in place and the entire assembly carburized in one heating at 1675° F. Brazed joints must pass a test of 40,000 psi.

ONE HEATING DOES 2 Jobs!



Carburizing and brazing of this motor starter assembly are done simultaneously in a single Ajax salt bath with one heating of the work. A water quench completes the job. A conventional carburizing bath produces a case depth of .015" in 50 minutes.

QUALITY IMPROVED—Costs Cut!



The laminations of this SAE-1010 steel stapler bracket are securely brass-brazed at the same time the surface is being carburized. Wearing surfaces are file hard. Distortion is less than .005". The entire carburizing-brazing operation was done in 20 minutes.

WARP-FREE HARDENING Plus BRAZING



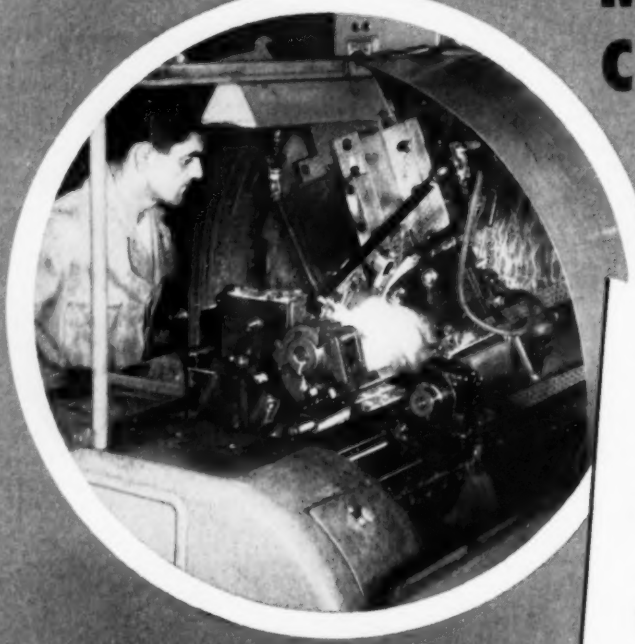
Warpage on this magnetic lock part is negligible thanks to complete protection during hardening in a neutral salt bath. The flange is securely brass-brazed to the steel cup in the same operation. Brazing metal is confined neatly to the joint—does not spread over the parts.



AJAX electric SALT BATH furnaces

World's largest manufacturer of heat-treating furnaces exclusively

WHAT'S YOUR GUESS ON THIS Machinability Comparison?



ENDURO STAINLESS STEEL BARS ARE —% AS MACHINABLE AS BESSEMER SCREW STOCK

Would You Say

(a) *42%* (b) *67%* (c) *100%*
(d) *33%* (e) *90%*

?

YOU CAN APPLY the high physical and chemical properties of ENDURO Stainless Steel to duplicate parts you're running now —and still get fast automatic production.

Free-Machining ENDURO Bars are cold-finished by Republic's Union Drawn Steel Division especially for that purpose. They provide close tolerances, accuracy of section, uniform soundness, and fine surface finish.

Two grades are fully 90% as machinable as Bessemer screw stock. If 90% was your answer to the question above, you've probably had experience with Free-Machining ENDURO Bars. If you haven't, Republic metallurgists will be glad to give you prompt assistance on applications, processing, and use. Free-Machining ENDURO also is available in hot-rolled bars and in wire. Get more details from your nearest Republic District Sales Office, or write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

Republic ENDURO®
FREE-MACHINING
STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

NOW - - - an improved water-mix base oil especially formulated for both cutting and grinding application



DASCO
SUPER SOLUBLE BASE

ONE phase of Stuart's continuous research program on metal-working oils and compounds has been directed toward the formulation of a better water-mix cutting and grinding fluid. A heavy duty type water-mixture that would improve machine efficiency on both classes of work, and which could be used at leaner mixtures than normally recommended for soluble oils.

FOR WATER-MIX CUTTING APPLICATIONS. A heavy duty water-mix cutting fluid base, capable of filling the gap between conventional soluble oils and straight cutting oils, must contain more than ordinary petroleum oil if superior performance is to be realized. The manufacture of Dasco Super Soluble Base incorporates a heavy duty base oil — widely known for its performance record on the toughest metalworking jobs.

The advantages gained from this unique feature include superior performance at leaner mixtures than other heavy duty water-mixes. Mixtures normally start at 40 to 1 for turning, drilling, milling, sawing, boring, reaming. Only on some surface broaching, and round hole broaching operations has it been necessary to use mixtures as rich as 15 to 1.

FOR WATER-MIX GRINDING APPLICATIONS. Cylindrical, surface, and centerless grinding operations call for a water-mixture with a higher detergency factor than that found in ordinary soluble oils. Better rust inhibiting and stability characteristics are required because of the leaner mixtures usually used for grinding. Dasco Super Soluble Base has been used for exceptionally long periods of time, at leaner mixtures than 100 to 1, the recommended starting mixture, with no problems due to rusting, separation or rancidity.

TWO WATER-MIXES BUILT INTO ONE. The combination of extra cutting value, high grinding value, excellent stability and great resistance to rancidity makes Dasco Super Soluble Base an ideal water-mix for both cutting and grinding — one that has been especially formulated to give top performance on both classes of work — at leaner mixtures than ordinarily recommended for other heavy duty products — and priced lower than normal for a product of such high quality. Send coupon for complete data.

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D. A. Stuart Oil Co.
EST 1865 LIMITED

TIME-TESTED CUTTING FLUIDS AND LUBRICANTS

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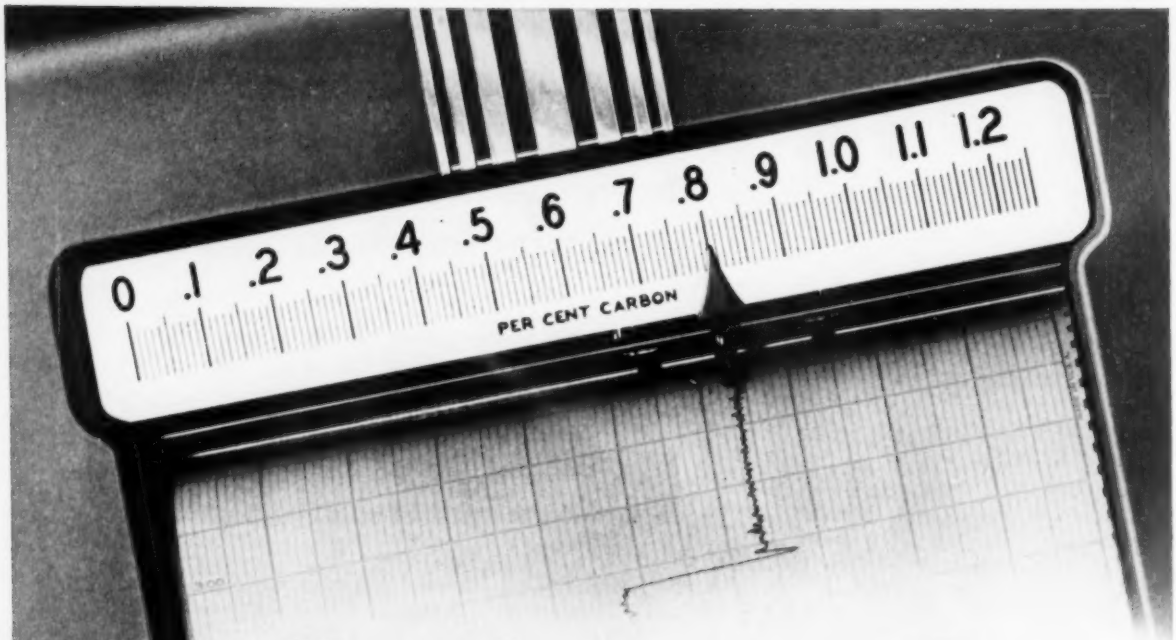
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D. A. STUART OIL CO., LTD., 2743 S. TROY ST.
CHICAGO 23, ILL.

Check One ☐ Have Stuart Representative Call
☐ Send Data On Dasco

Your name .....

Title .....



Here's a record...

that few have ever seen!

Ninety-nine out of 100 metallurgists and heat-treaters have not yet had a chance to see a continuous instrument record of the carbon in a furnace's carburizing gas. And probably not 99 out of 10,000 production men have seen such a sight.

But neither group is going to be unfamiliar with this advance for much longer, because this valuable information is now as easy to get as a temperature record. It comes from a Micromax Carbon Recorder, which is part of the brand new L&N Microcarb Control.

Already several dozen plants have ordered Microcarb equipment. Here and there a present user is letting his friends drop in for a peek. So, the Carbon Record will soon be pretty generally known to men who look for the modern way to cut carburizing costs or improve carburized parts.

Every metallurgist and heat-treater will probably have his own idea as to exactly what this instrument can mean in his plant. Technically, it shows only the percent of active carbon in the atmosphere of a Homocarb Furnace; but practically, it shows the surface carbon content of the parts being carburized! Used with Microcarb Control, it means that "the carbon you set is the carbon you get." You can control the surface carbon, regardless of whether you want a shallow or deep case; on familiar steels or the newer alloys.

Only Homocarb carburizing equipment of our new Series H can be used with Microcarb, because the furnace and its temperature control must be designed to meet the needs of atmosphere regulation. Specific features are a soundly designed electric furnace with solid-bottom retort, improved fan housing and work support, and aerodynamically designed discharge jets. Micromax temperature control of the Duration-Adjusting Type is included.

The full Microcarb story will be mailed on request. Address either our nearest office, or 4927 Stenton Ave., Philadelphia 44, Pa.

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H. J.
Here's a really fantastic letter!
P.W.

BANNER TOOL COMPANY

BANNER tools DETROIT — *Fine* TOOLS FOR INDUSTRY

17243 FILER AVENUE • TWINBROOK 2-4900

DETROIT 12, MICHIGAN

June 16, 1952

Cities Service Oil Co.,
3049 E. Grand Blvd.,
Detroit 2, Michigan
Attention: Mr. P. E. Watts

Dear Sirs:

We called upon the services of your lubrication engineer, Mr. A. J. Blake, in reference to a serious staining condition which we were having with our soluble oil. He analyzed this condition and recommended one of your Chillo Oils. This oil was tried and the rust condition eliminated to our satisfaction.

To our surprise on his next visit he was dissatisfied with our tool life and suggested we use a soluble oil called "Chillo A". Now not only do we have clean machines, but tool life has been increased 20%! While in our plant he asked permission to "look around", which, of course, was granted.

We were using a tapping compound with precision ground taps in order to hold to close tolerances. We did not consider tap breakage excessive but the removal of broken taps was sometimes rather expensive. He recommended we use "Chillo 10Z". Then came the surprise of our lives! With Chillo 10Z we have gone to commercial ground taps (a 300% savings) and can still hold our same tolerances, with a sharper thread, increasing tap life a minimum of 20% plus eliminating expensive removal of broken taps!

We also have a production stamping job which required a new set of dies every month. On his recommendation we tried Chillo 10Z with these dies. Now our die life has increased to at least two months...a saving in die life of 100%, disregarding labor costs. We also increased production 200% per die sharpening!

We tried the same oil on our broaching operation and found that instead of making two cuts we can get the same results now with one. We were using one of your competitors' hydraulic oils and you told us it was a "good oil" and would give us satisfactory performance. BUT, GENTLEMEN, WITH THE EXCELLENT SERVICE YOU HAVE GIVEN, PLUS THE TIME AND MONEY SAVED, YOU MAY REST ASSURED THAT ALL OF OUR LUBRICATING REQUIREMENTS WILL BE PURCHASED FROM YOU.

Yours very truly,

BANNER TOOL COMPANY

S. F. OLESAK

SFO:sd

Color Coded
HARSHAW CHART OF THE ISOTOPES*

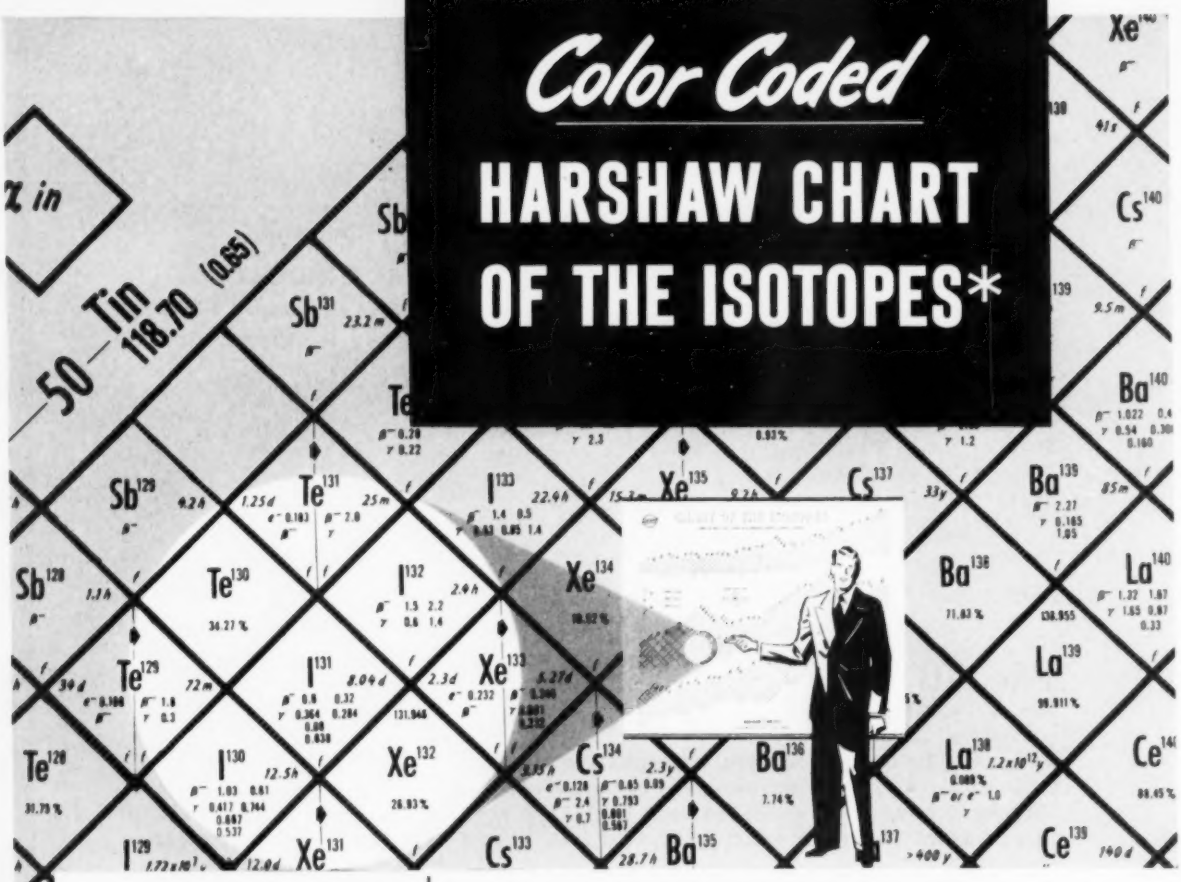


Chart Features

- **Element Name**
- **Atomic Number**
- **Atomic Weight, 1952 Revision**
- **Atomic Mass Data**
- **Thermal Neutron Cross Section**
- **Element Symbol**
- **Stable Isotopes Color Coded in Blue**
- **Naturally Radioactive Isotopes Color Coded in Green**
- **Artificially Radioactive Isotopes Coded by Half-life in 6 Colors**
- **Radioisotope half-life**
- **Modes of Radioactive Decay**
- **Radiation Energies in Million electron volts**
- **Isomeric States**
- **Isomeric Transitions**
- **Nuclear Transmutation Code**
- **Percentage Abundance of Naturally Occurring Isotopes**
- **Fission Data (thermal fission of U^{235})**
- **Lithographed in 8 Colors Plus Black and Gray**

Corrected to February 1, 1953

Compiled and Edited by
JOHN R. BRADFORD, Ph. D.
Director Radioisotopes Laboratory,
Case Institute of Technology

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8 Code Colors Identify Isotopes and Half Lives

The Harshaw CHART OF THE ISOTOPES is arranged to make available, in an easy to use form, all the useful information about isotopes. This new and unusual chart is designed and lithographed in ten colors to make possible rapid identification of isotope half-life and nuclear stability.

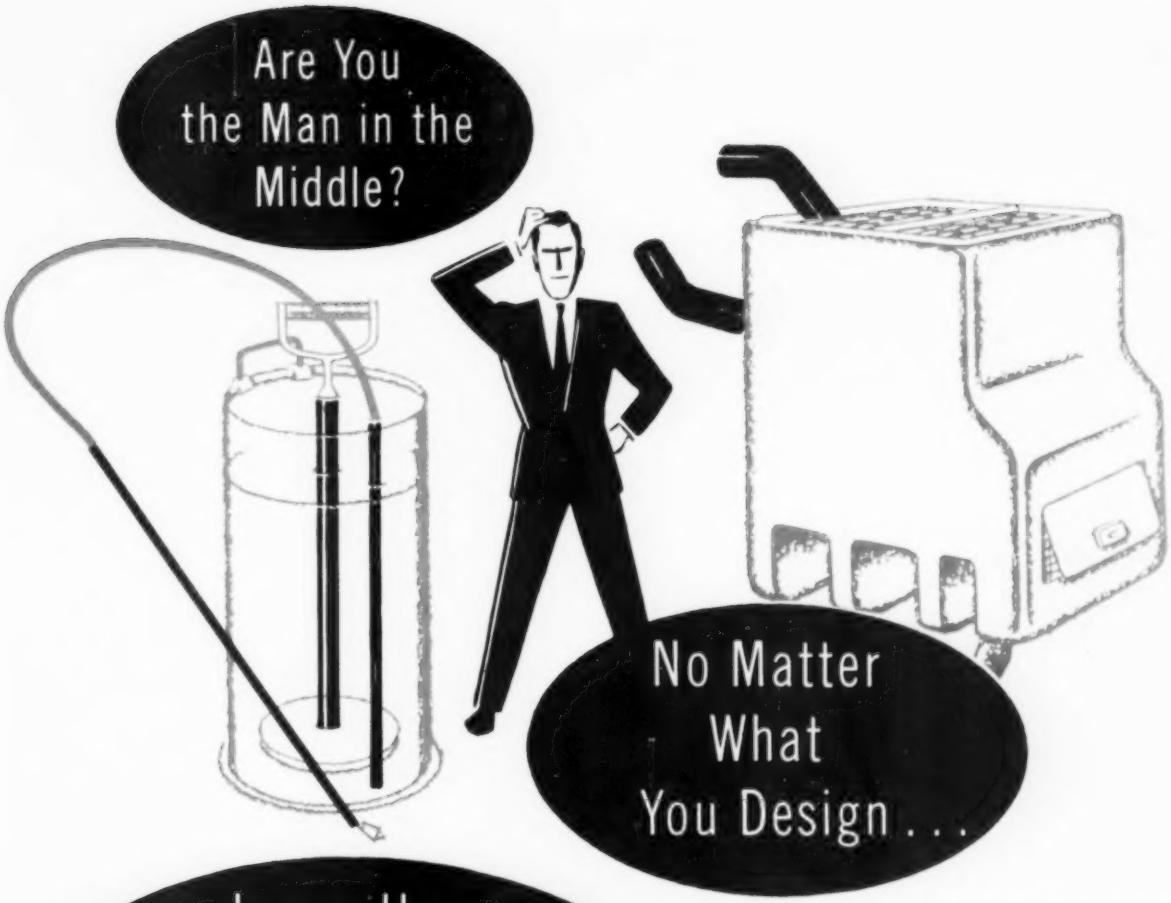
The CHART OF THE ISOTOPES is 60 by 48 inches with metal edges for hanging. Printed on Texoprint, a new plastic impregnated fibre paper developed for navy charts, it is washable, non-creasing and extremely tear resistant. The guide book sent with each chart outlines instructions for reading the chart, and summarizes many chart applications.

H-10950 CHART OF THE ISOTOPES—1953 edition, complete with explanatory booklet. (postage paid) . . . Each **$10.50**
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DIVISION OF THE HARSHAW CHEMICAL CO., CLEVELAND 4, OHIO

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Learn How H&H METALFLO* the Brazed Brass Tubing Can Save You Money

There is no need to be in the middle any longer. No matter what you design, there is bound to be an H & H Tube that will serve your tubing requirement better and perhaps even save you money. Examine the product that you make. Check the tubing. Are you using Seamless Brass and Copper where H & H Metalflo would do an equally good job—for less money? Always remember that when pressure is not a factor, as in the products illustrated above, H & H Metalflo, the economical brazed brass tubing, can save you real money. Originated and manufactured exclusively by H & H, Metalflo is still another reason why experienced tubing buyers everywhere say, "For tubing that will last we look to H & H first."

H & H TUBE AND MANUFACTURING COMPANY

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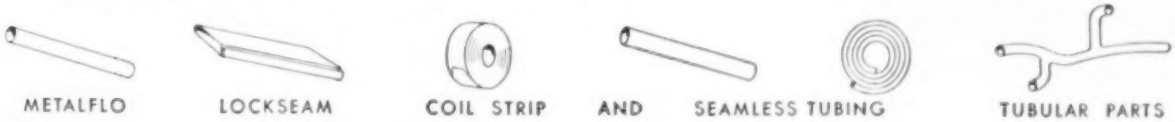
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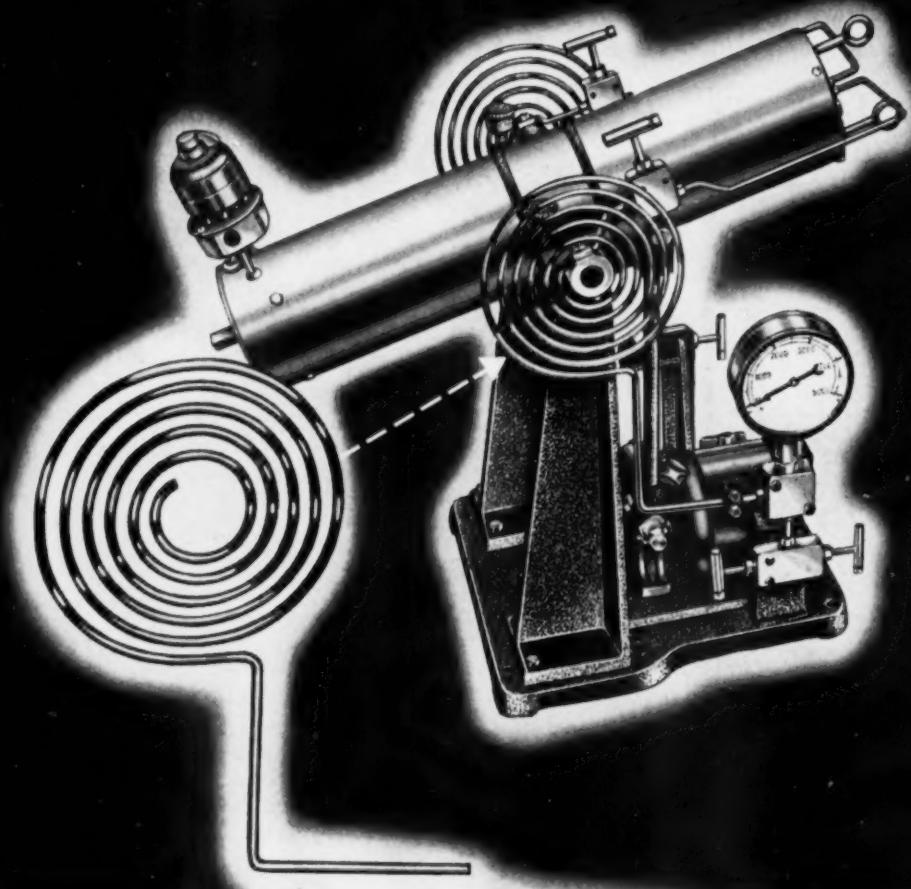
Outside Dimension		Wall Thickness
3/16 thru 3/8	x	.015 to and including .025
3/8 thru 13/16	x	.012 to and including .035
13/16 thru 1"	x	.015 to and including .035
1" thru 1 1/16	x	.020 to and including .035
1 1/16 thru 1 1/8	x	.025 to and including .035
1 1/8 thru 1 3/16	x	.032 to and including .035

Price Sheets Available Upon Request



METALFLO LOCKSEAM COIL STRIP AND SEAMLESS TUBING TUBULAR PARTS

Windpipe for a peaceful H-bomb



You can call it an H-bomb if you like. Some people do. Technically, it *is* a hydrogenation bomb or, simply, a super-pressure vessel. Uses for it are legion but not warlike.

Researchers in rubber, plastics, pharmaceuticals, petroleum, and solvents pilot their hydrogenation, oxo-reaction, polymerization and other jaw-breaker problems in its gizzard—under high pressure.

To speed-up chemical reactions, the vessel is rocked 38 times a minute. Pressurizing a see-sawing chamber is in itself a neat trick: when pressures of the order of 60,000 p.s.i. are required you might become discouraged or concerned.

American Instrument Company, Inc., maker of Super-pressure equipment, introduces the pressure through a spiral windpipe. They had some trouble through tube breakage but that was before they tried Superior 304 Cold-drawn Seamless Stainless Steel Tubing. Superior gives them just the flexibility and fatigue strength needed for cyclic operation, plus chemical resistance and burst pressure to spare. Spirals of Superior 304 are easier to bend, last longer. And American Instrument reports them dimensionally uniform, smooth and free from surface imperfections.

If you haven't found small tubing in the analysis, size, and finish you want, or if you think there's little difference in tubing or tubing experience, Superior invites your inquiry. Superior Tube Company, 2008 Germantown Avenue, Norristown, Pennsylvania.

Round and Shaped Tubing available in Carbon, Alloy, and Stainless Steels; Nickel and Nickel Alloys; Titanium, Zirconium, and Beryllium Copper

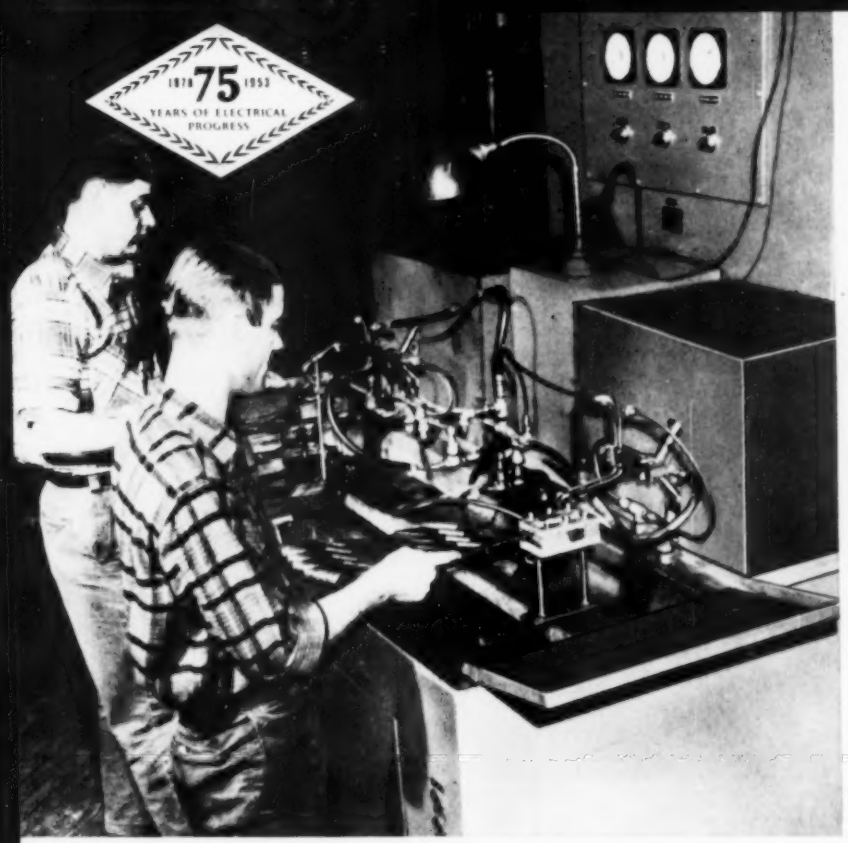


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THE BIG NAME IN SMALL TUBING

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. UNderhill 0-1331

All analyses .010" to ⅜" O.D.
Certain analyses (.035" max. wall) up to 1⅜" O.D.



INDUCTION HARDENING RACK BARS AT BURROUGHS CORPORATION.

Hardening Costs Cut 65 Percent With G-E Induction Heaters

"By changing to induction heat, we have reduced rack-bar hardening costs as much as 65%," reports Stanley Bankett, Jr., heat-treating foreman at the Plymouth Plant of the Burroughs Corp., Detroit, Mich.

When using old heat-treating methods for hardening parts, Burroughs was faced with expensive straightening operations to eliminate distortion. Now, by applying selective induction heat with G-E heaters, Burroughs heat-treats only the areas that require hardening—thus preserving the original shape of the bar while maintaining top quality.

Improved working conditions are another benefit now enjoyed by Burroughs, because compact G-E heaters eliminate the discomfort of radiant heat and provide cleaner, more comfortable working areas.

Burroughs has added six G-E heaters since first adopting induction heat. Today, they use induction heat for a variety of heat-treating operations involving many business-machine parts. In each case, substantial savings have resulted.

This high-quality selective heating at lower cost is available to you. To learn how you can profitably apply G-E induction heat to your operations, contact your G-E Apparatus Sales representative. And write now for bulletins on G-E induction heaters to General Electric Co., Sect. 720-103, Schenectady 5, N. Y.

You can put your confidence in—

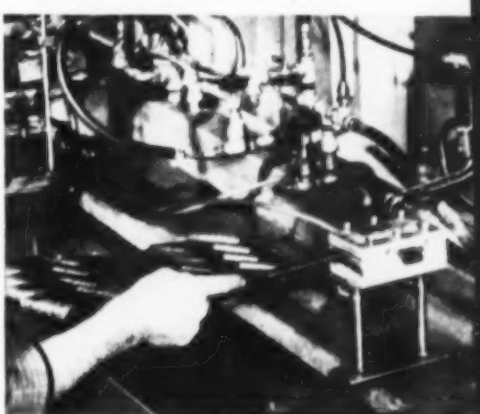
GENERAL ELECTRIC



SELECTIVE HARDENING occurs at darkened areas which must resist excessive wear. Maximum hardness is obtained without distorting bar.



ACCURATE HEAT CONTROL in the simple induction fixtures shown above and below assures uniform hardness of every bar.



HIGH-SPEED PRODUCTION is typical of G-E induction heating. Over 1500 parts are heat-treated daily in this versatile G-E 15-kw unit.



Acid Disc Inspection backed by *Ultrasonic Testing* is just one of many Carpenter quality controls.

IF YOU USE TOOL STEEL, THESE ARE FACTS YOU SHOULD KNOW

When you make or use a tool or die you invest a sizable sum of money. And there are steps you normally take to protect your investment. You make sure the design is right. You follow through with accurate toolmaking and correct heat treating. But there is *one* factor involved in the success of your die, over which you have only indirect control. That factor is the *soundness* of the die steel you start with. After all, if the steel itself isn't right, you needlessly risk your entire investment.

How can you be *sure* the die steel you use has what it takes to assure good tools? The answer lies in the painstaking controls regularly practiced by the steel manufacturer. Listed here are the four important tool steel controls pioneered by Carpenter to give steel users like yourself the protection you need. Before you place that next tool steel order, ask yourself, "Does our steel supplier guarantee these four quality controls in the die steel we use?" Then remember: You can be *sure* of them when you specify Carpenter Matched Tool and Die Steels. And you don't pay anything extra! The Carpenter Steel Company, 139 W. Bern St., Reading, Pa.

4 Tool and Die Steel Developments *Pioneered by Carpenter*
Help Carpenter Customers Cut Costs, Improve Die Performance

Since 1929:
HOT ACID DISC INSPECTION has been standard practice at Carpenter. To Carpenter customers it provides full assurance that Matched Tool and Die Steels are internally sound, shipment after shipment.

Since 1930:
The TOUGH TIMBRE TEST has assured Carpenter users a wider safe hardening range, greater dependability in performance.

Since 1933:
The TORSION IMPACT TEST has provided Carpenter Matched Tool and Die Steel users with more complete heat treating information that leads to better tools and dies.

Since 1940:
The CONE TEST, used to check and control hardenability of Carpenter water-hardening Matched Tool and Die Steels, has made sure that sections of the same size have uniform hardness penetration in lot after lot.

Carpenter STEEL

Matched Tool and Die Steels



Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U.S.A. and Canada

Metal Progress . . . . . August 1953 Vol. 64, No. 2

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Meeting Emergency Demands for Steel

Here are records of six emergencies faced—and met— by Ryerson Steel Service:

Shutdown Averted

4:30 p.m.—1000 lbs. bar stock urgently needed to avert shutdown of night operations. Order processed by office at 4:35; goes to warehouse at 4:41. Steel leaves Ryerson plant at 5:30; arrives at customer's plant (7 miles away) at 6:05 p.m.

Shipped in 1½ hours

10:15 a.m.—two plates needed immediately. With customer still on phone, Service Department alerted. Steel sheared to size and on its way by 11:45 a.m. same morning.

Night Shift Comes Through

3:00 p.m.—order phoned in for 20,000 lbs. of sheet steel. Needed (90 miles away) at 8:00 a.m. next day. Working through the night, Ryerson warehouse crew cuts the steel—loads it on truck that leaves at 6:00 in the morning. Shipment arrives at customer's plant on time.

Breakdown Saturday—Production Monday

Saturday—11:45 a.m. Emergency call. 8″ alloy steel round needed to repair breakdown of main shaft. Cut during lunch hour, the 1700-lb. bar is immediately trucked to airport; loaded on cargo plane. Customer meets plane on arrival in distant city. Repairs are completed Sunday; full production resumed on Monday.

Delivery 600 Miles Away—7 Hours

3:00 p.m.—200 lbs. of flat bars, in cut lengths, needed in a hurry 600 miles away. Just 2½ hours after receipt of order, plane takes off with steel from Ryerson. At 10:51 p.m. same day, customer has his steel.

Still Hot When Delivered

11:15 a.m.—Manufacturer reports breakdown; needs 2″ x 72″ x 10′ plate at once—must be flame cut. Plate delivered at 2:15 p.m., still hot.

Of course, out of thousands of orders, we can fill only relatively few at such breakneck speed. However, in emergencies, the world's largest steel service organization, with 15 interconnected plants, is your best source for steel. And, despite some shortages, you can also count on Ryerson for most every day-to-day steel requirement. So when you need steel—carbon, alloy, stainless—call your nearby Ryerson plant.

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Cold Shaping of Steel by Compression Reaches Commercial Applications

By ARTHUR H. ALLEN
Technical-Business Consultant
Cleveland

COLD SHAPING or displacement of steel under heavy compression is a relatively new technique in metal-working which appears to be opening up a new field of product design and manufacture, with significant advantages in terms of cost, quality and metal conservation. As outlined in the historical article in the July issue, p. 97, the process originated in Germany well over 20 years ago and was confined there principally to ordnance matériel like mortar and artillery shells and cartridge cases. The process has been popularly called "cold extrusion", but it is considerably more than that. Actually, it is a combination of cold forming methods, including "forward extrusion" and "backward

Three Keys to Cold Extrusion

extrusion", drawing, coining, ironing, compacting and expanding, all done in conventional hydraulic presses fitted with cylindrical punches and circular dies.

Starting with a cylindrical slug of steel, successive press operations work it cold to the final shape, holding exceptionally close dimension limits, with superior finish and virtually no loss in machine shop scrap. Cold working develops high tensiles in low-carbon steels, without necessity for final heat treatment.

Whatever you prefer to call the method – cold press forging, cold extrusion, compression forming, or something else – the fact remains that its commercial possibilities loom large. Mullins Mfg. Corp. of Salem, Ohio, has set about to explore them, after nearly ten years of engineering research and pilot-line experience, as well as successful production of 3,000,000 shells (105-mm. artillery and 81-mm. mortar) over the past five years. Mullins, incidentally, calls its process "Koldflo".

Sparking Mullins' activity in compression forming has been a German engineer, Ben Kaul, who came to the U. S. 26 years ago, worked extensively in the automotive stamping field around Toledo and joined Mullins in 1942. He is regarded by his associates as something of a genius in pressed metal techniques and it is not far-fetched to suggest that Mullins might well have named its baby "Kaulflo".

A recent visitor with metallurgical background accused the people at Salem of "doing things to steel which were never intended to be done". When you watch the process in operation you are inclined to agree. But such an attitude is just standing in the way of progress. It has, in fact, been the inability to buy hot rolled and pickled steel rounds in large diameters (up to 7 in.) that has held up the commercial advancement of Koldflo. Shell requirements were taking practically the entire mill output. Even material for experimental work had to be begged, borrowed and otherwise usurped or "converted". Fortunately, this situation has now eased, and five steel mills have indicated they are ready to ship hot rolled round bars in large sizes for nonmilitary uses.

The process takes a round slug of ordinary A.I.S.I. 1012 steel weighing 17.75 lb., and in a series of four press operations compresses it into a 15-in. torsion tube about 4 in. in diameter, closed at one end and offset on the inside at the other. Yield strength of the metal in the finished part is 90,000 psi., elongation 16%, hardness Rockwell B-93 and weight 17.4 lb. The only scrap is 0.35 lb. machined off the open end. Concentricity of inside and outside diameters is within 0.002 in.; wall thickness varies no more than 0.004 in.; surface finish is under 50 micro-in. r.m.s. No final heat treatment or machining is required, other than at the top rim. This is a commercial part for a tandem rear axle assembly for trucks and is produced in quantity at 20% less cost than the former seamless tube with welded base.

The secret? Well, there is really no "secret" involved. Rather, there are three basic keys to the process, regardless of the part being made.

First and most important is the design of punch and die. They are of ordinary oil hardening toolsteel, but their geometry must be worked out meticulously.

Second key is the lubricant used on the stock. This is where the original German practice played an important part. The steel is first pickled, then rinsed, dipped in phosphate solution of the "Bonderite" type, coated with a special lubricant ("Parcolene") and finally dunked in an ordinary soap solution. The phosphate coating adheres tightly, flows with the metal in the die, absorbs and holds the lubricant, and so prevents seizure between metal and tools, avoids scoring of the work and permits easy removal of the part from the die. Thus, a cylindrical shape can be formed from a solid slug with no draft or taper on the inside. The phosphate surface treatment is applied to the original stock and to the piece after every intermediate anneal.

Phosphating (or Bonderizing) steel in extrusion operations was introduced in Germany in 1930 by the German licensee of Parker Rust Proof Co., according to F. J. DeWitt of that company (*Metal Progress*, August 1952, p. 92; July 1953, p. 97). Mills in the United States began using it around 1940 for cold drawing seamless steel tubing. Following the war, when German success in "cold extrusion" of steel shells and cartridge cases was publicized, interest in the idea was rekindled here, especially among ordnance officers. The coating and associated lubricant were described by Adolph Bregman in *Metal Progress* for December 1951 and by Allen G. Gray in the April 1953 issue, while work at Heintz Mfg. Co., Philadelphia, in extrusion of low-carbon steel shells and rocket heads was reviewed by the Editor in "Critical Points", May 1952 issue.

Third key to the Mullins process is the unit pressure to be used in the various press operations, which, of course, governs the speed of

the descending punch, once it meets the steel. Surprisingly, these pressures are not inordinately high. It has been reported that 100 tons per sq.in. is sufficient for forward extrusion of low-carbon steel.

Various sizes of presses are used by Mullins, all of standard design and of 1000, 2000 and 3000 tons (Fig. 1). At its Liberty shell plant, equipped by the government at a cost of $10 million, the four press lines are mostly 1000-ton and 2000-ton units. In the Koldflo department of its Warren plant two 2000-ton presses are now in operation on experimental work and will become part of a production line eventually to include four new long-stroke (30-in.) hydraulics of 3000 tons capacity. They will be installed and ready to go by November as a part of a $2,600,000 facility, supplemented by the necessary annealing, pickling and phosphating equipment.



Fig. 1 – Operator Loads Partially Finished Piece Into Die of 3000-Ton Hydraulic Press. With Punch in Raised Position. Four of these presses and two of the 2000-ton units comprise a production line for cold shaping on a volume basis

PRODUCTION OF VARIOUS SHAPES

This setup will be able to handle production quantities of parts weighing up to 100 lb. By production quantities is meant 50,000 and up. Concurrently, Mullins Mfg. Co. is licensing other firms in the pressed steel industry to install the process, offering both a design engineering service to help convert or create parts for the system, as well as a development department to try out designs and production procedures, and establish costs. Careful preliminary studies are necessary, since a company with a couple of idle presses and some unused pickling tanks and annealing ovens cannot simply pull a switch and start cold extrusion.

In its early stages, the limits of the process are not easily definable. Simple shapes are already being produced, such as heavy-walled cylinders, hubs and other concentric forms which may have integral studs, offsets of many types and combinations, multiple flanges, lands or flutes, integral webs or separators. Best possibilities seem to be in the weight range of 10 to 30 lb., although many parts have been fashioned experimentally in weights ranging from 1 oz. to 80 lb.

Pieces formed by this unique compression technique can be carburized readily. They seem to show less distortion than the same shapes made by conventional operations – possibly because the intense compression during forming is so equally distributed in all regions of the piece. Tensile strengths of the low-carbon steel can be controlled between 85,000 and 110,000 psi. by suitable coordination of annealing temperatures and forming pressures.

Commercial elongation requirements can be met easily. Hardnesses may be varied from 90 to 100 in the Rockwell B-scale, in thick or thin sections. Due to the method of manufacture and the relationship between cold work and induced hardness (tensile strength), this hardness exists throughout the full section. Another claim for the process is so-called "interlocked" grain flow, which is advantageous in some parts where a sound, leakproof base or web is demanded.

Two of the most unusual examples of Ben Kaul's ingenuity are shown in accompanying illustrations. Figure 2 is a cylindrical shape with an integral web near the base and having different wall thicknesses above and below the web. By varying the punch and die design and travel, this web might be placed anywhere along the cylinder. Grain flow follows the contour of the web and walls, making each chamber leakproof. The design is ideally suited to an ordnance piece such as a rocket head, for example, which has the propellant charge in one chamber and the detonating charge in the other.

Another "stunt" is shown in Fig. 3, a piece which has round top and bottom sections, of different diameter and wall thickness, with a square center section, both inside and out. It was manufactured principally to show the

Examples of Cold Extrusion

versatility of the process, and not for any particular use.

Figure 4 is an example of a production part – a 41-lb. cylinder for a hydraulic-air accumulator (to replace the starter on a new type of prime mover). It was formed from 1010 steel, with scrap loss of only 1 lb. Inside surface has smoothness of 10 micro-in. r.m.s. It may be honed readily – or possibly flash chromium plated – to meet a 2-micro-in. specification. Proof testing was at 14,000 psi. Cost studies show it can be made for $10 as against $18.50 for the original fabricated design. Parts of this same general contour but of widely different proportions, wall thicknesses and hub heights (top and bottom) are obviously possible. Flanged lips can be put either on top or on bottom. Another example of the versatility of the process in making internal shapes which would be most expensive to machine is Figure 5. Lands or flutes can be formed on either inside or outside walls, at top or bottom, in any length or combination which permits withdrawal of punches from work and the work from dies.

A small cylinder for a die stripper – a closed chamber with integral inside and outside stud, weighing 2 lb. – was produced from 1010 steel in three operations – two backward and one forward extrusion – at a cost of $3. Capable of withstanding 30,000-psi. internal pressure, it replaces a previous forged and brazed design, requiring 7 lb. of Type 430 stainless and costing $4. The unit, by the way, is a new type of "hydra-spring" which contains a fluid of vanishingly small compressibility to produce the desired resilient action.

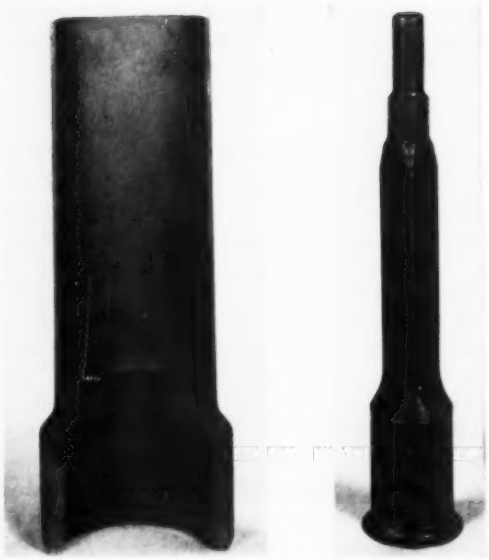
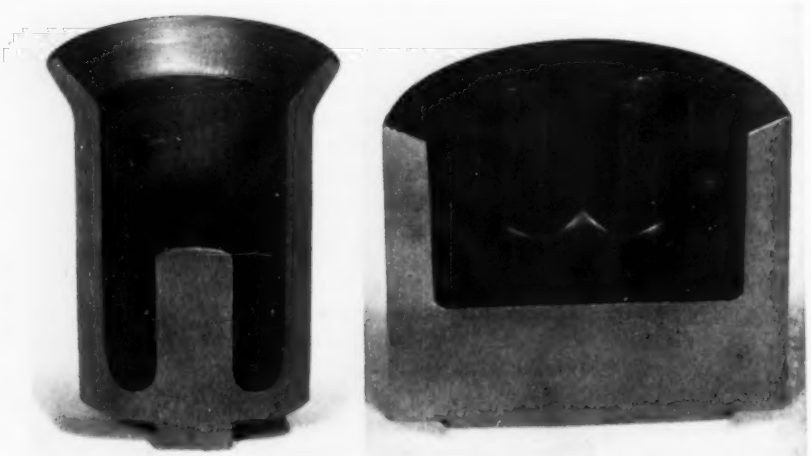


Fig. 2 – Integral Web or Separator Is Formed in a Double Cold Shaping Operation, as in Sectioned Piece at Left. Web may be of any thickness or contour, and located at any point in the tube. Grain flow can be "crossed" to eliminate porosity, making each chamber leakproof

Fig. 3 – Unusual Demonstration Piece at Right Was Produced Entirely by Punch and Die Operations. Top and Bottom are round inside and out, while the center portion is square both inside and out. No machining was required

Fig. 4 (Left) – Both Forward and Backward Extrusion Are Involved in This Part. The integral inside and outside stud, formed without any machining, is fully concentric with inside and outside walls

Fig. 5 (Right) – Heavy Cylindrical Cup With Interior Flutes



These are only representative examples of where Mullins Mfg. Co. is going with "Koldflo". The company has great confidence in the future of the method but obviously it cannot know just what the outlines of tomorrow will be. Competition with forgings, stampings and castings is certain, and that is a tough assignment. However, the feeling is strong that where a process can establish itself in terms of quality and of cost there need be small concern over markets.

And, as Ben Kaul repeatedly and emphatically will tell you, "This is only the beginning!"

Factors Influencing Cold Extrusion of Steel

By H. J. PESSL, Assistant Works Manager, Defense Products Division
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and H. H. HAUTTMANN, Director of Research and Development
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THE FIRST PORTION of this article, published in last month's *Metal Progress*, gave the historical background of the cold extrusion process for steel, and recounted some of the early experiments by Hauttmann and Pessl in Germany that resulted in the selection of phosphate coatings as lubricants. The tests were made by determining the extrusion pressure required with various types of lubricants.

Extruding pressure depends not only upon the surface coating and type of steel being extruded, but also to a large extent on die design. The flow of material in extrusion resembles deformation in wiredrawing. Figure 6* shows the cross section of a round bar which was split in two and marked with parallel lines. The two halves were then put together and extruded with 70% reduction in cross section. The flow lines show that most of the deformation takes place in the core rather than in the outer surface of the part. Overstressing of the core, such as often occurs in deep drawing, is thus improbable. While in cold drawing the tensile strength and the danger of internal fracture definitely limit the degree of drawability of the material, the extrusion process is virtually free of these restrictions.

Experiments to determine the influence of the angle of the extrusion orifice (die angle) have proven conclusively that nozzles with a small angle require the lowest extruding pressure and result in the most favorable fiber flow. Radial stresses, however, are high and are likely to cause fracture of the die. The die angles used in industrial cold extrusion are generally chosen with these stress considerations in mind, and range between 125 and 130°. Extrusion pressures and property changes in the extruded steel have been given somewhat less attention. Wall thickness of the dies is held to a minimum for obvious reasons, and they should be backed by shrink rings so as to protect against fracture and to permit the use of a small die angle.

A series of experiments was performed on 25 steels; 11 of the most important are listed in Table II, which shows chemical composition, type or quality of steel, mechanical properties, and notched-bar impact resistance. The steels range between 0.08 and 0.50% carbon; tensile strength lies between 50,000 and 110,000 psi. The blanks were machined from hot rolled bars 1½ and 4 in. in diameter and subsequently normalized. The aluminum-bearing steels were cooled in air from the normalizing temperature at a sufficiently rapid rate (18° F. per min.) to render them resistant to strain aging. (Resistance was determined by impact test on modified Charpy-type keyhole notched bars cold pressed 10% and heated ½ hr. at 480° F.) Steels No. 1 and 8 represent the low and medium-carbon, aluminum-bearing, nonaging types of steel which are used most frequently in the industrial cold extrusion of products subjected to high impact stresses. For less highly stressed parts, steels 2 and 7 proved to be sufficient. The



Fig. 6 — Cross Section of Bar Marked With Parallel Lines Shows Flow Lines After Extrusion. Reduction of area was 70%

*Figures and tables are numbered consecutively from the first installment in the July issue.

Table II – Chemical Composition and Tensile Properties of Steels Tested

Steel	Quality or Type	Chemical Composition, %							
		C	Si	Mn	P	S	Cu	Al	N
No. 1	Special steel for cold extrusion	0.08	0.07	0.33	0.019	0.022	0.11	0.059	0.006
2	Rimmed steel for deep drawing	0.10	–	0.41	0.025	0.033	0.13	–	0.008
3	Nonaging boiler plate steel	0.09	0.10	0.53	0.024	0.032	0.14	0.025	0.007
4	Killed boiler plate steel	0.11	0.10	0.45	0.020	0.032	0.12	–	0.009
5	Nonaging free-cutting steel	0.12	0.22	0.68	0.035	0.138	0.15	0.054	0.009
6	Special free-cutting steel	0.12	–	1.43	0.026	0.148	0.14	–	0.008
7	Case hardening steel	0.16	0.12	0.48	0.028	0.032	0.12	–	0.007
8	Nonaging boiler plate steel	0.24	0.28	0.50	0.041	0.029	0.11	0.040	0.006
9	Nonaging free-cutting steel	0.27	0.26	0.73	0.036	0.200	0.15	0.057	0.008
10	Heat treatable structural steel	0.45	0.24	0.80	0.043	0.031	0.10	–	0.007
11	Bessemer rail steel	0.50	0.20	0.90	0.059	0.026	0.06	–	0.016

free-cutting steels (No. 5, 6 and 9), which are especially suitable for extrusion when machining is required, have not yet been extensively used commercially, nor have the higher carbon steels No. 10 and 11 (0.45 and 0.50% carbon).

In the experiments, blanks 0.787 in. in diameter were extruded through dies with 40, 90, 126 and 180° angles to rods 0.464 in. in diameter, corresponding to a 65% reduction of area of cross section. The blanks were phosphate-coated in a Bonderite bath (trade name of Parker Rust Proof Co.'s phosphate coating), and slightly lubricated with ball bearing fat. The extruded specimens were subdivided into sections for microscopic examination and determination of hardness and notch toughness. The Vickers pyramid hardness test was used on a cross section of the bar, while the impact tests were carried out on the extruded round bar with Izod-type V-notch (Type Y specimen) after annealing 1 hr. at 480° F.

The test results are shown in Table III. It will be noted that the extruding pressure and hardness increase with increase in die angle for all the steels; notch toughness decreases, especially for the harder steels. Least affected by die angle is aluminum-bearing steel No. 1.

Extrusion pressure also goes up with increasing tensile strength. Average, maximum and minimum values compiled from calculations on the 11 steels for the ratios of extrusion pressure to lower yield point and to tensile strength for the four different die angles are shown in Table IV and may well serve as a basis for the approximate determination of the extrusion pressure for intermediate die angles. For a die angle of 126° (generally used in manufacturing processes) and a reduction of cross section of 65%, the extrusion pressure averages 5.1 times the lower yield strength and 3.1 times the tensile strength of the normalized steel. For harder steels these ratios tend to decrease.

At a given degree of cold deformation (65%) the Vickers hardness of the extruded speci-

Table III – Effect of Die Angle on Toughness, Hardness and Extrusion Pressure

Steel	Notch Toughness,* M-Kg. per Sq.Cm., at Die Angle of				Vickers Hardness† at Die Angle of				Extrusion Pressure in 1000 Psi at Die Angle of			
	40°	90°	126°	180°	40°	90°	126°	180°	40°	90°	126°	180°
No. 1	13.5	13.5	12.0	12.6	194	198	198	192	119	142	175	209
2	10.0	9.3	10.0	8.5	204	212	215	212	131	145	170	205
3	12.5	11.7	11.9	9.5	210	218	214	218	136	163	180	213
4	11.3	10.2	7.8	8.7	205	231	222	221	131	145	172	218
5	9.8	11.1	6.3	6.5	218	220	228	237	136	156	180	242
6	9.6	8.5	8.8	7.0	224	241	248	230	145	165	185	243
7	9.0	10.4	7.7	9.5	230	238	258	242	156	175	202	266
8	13.0	10.6	11.0	7.5	272	275	285	290	160	183	213	279
9	11.4	10.7	9.4	10.2	250	260	262	284	170	192	218	284
10	6.0	6.2	4.0	3.0	310	372	372	375	225	235	270	347
11	10.2	4.5	3.4	4.2	354	355	376	374	261	260	291	371

*Izod impact test; Type Y specimen, "Metals Handbook", 1948 Ed., p. 113, Fig. 5. †Average of four tests.

Table II (Cont.) — Tests on 1½-In. Normalized Bars

Yield Point in Psi.		Tensile Strength Psi.	Elongation	Reduction of Area	Notch Toughness	
Upper	Lower				Unaged	Strain Aged*
35,600	34,200	50,000	40%	75%	24	22
30,000	30,000	51,200	37	62	18	1
31,300	31,300	52,500	39	64	21	13
34,200	32,700	54,000	37	70	19	1
38,400	38,400	60,000	32	53	16	8
40,000	40,000	61,200	28	44	21	5
42,500	41,200	62,500	31	65	18	1
45,500	41,200	71,000	29	50	16	10
47,000	47,000	74,000	31	57	14	10
55,500	55,500	96,500	21	36	4	1
61,000	61,000	110,000	18	30	1	1

*10% cold compressed ½ hr. at 480° F. and aged.

mens is 3.9 to 4.2 times the tensile strength of normalized steels when expressed in 1000 psi. At the smallest die angle of 40° the hardness is 3.2 to 3.5 times the tensile strength in 1000 psi. Increasing the die angle from 126 to 180° does not noticeably affect the hardness.

Notch toughness of the extruded specimens is remarkably high, especially in the direction of flow, considering that the results of the Izod impact test closely approach those obtained with the Charpy test. The Izod values for steels 10 and 11 when extruded are even higher than the corresponding figures for normalized steels, while all the other steels have higher notch toughness in the normalized and strain aged condition. (See Table II.)

The effect of a low-temperature stress-relief anneal (1 hr. at 480° F.) on impact resistance of the extruded steels is erratic. This is doubtless caused by the overlapping influences of aging embrittlement and stress-relief, working in opposite directions. An anneal at a somewhat higher temperature (between 750 and 930° F.) would most likely have had a more uniformly beneficial effect upon notch toughness. Impact resistance, like hardness, is affected most noticeably by increasing the die angle from 90° to 126°.

Effect of Reduction of Area

To determine the effect of reduction of cross-sectional area on extrusion pressure and notch toughness, a special series of experiments was carried out on the 25 steels. Results for notch toughness obtained on the 11 steels listed in Table II are compiled in Table V. The dies used for these experiments had an angle of 126°. The phosphated and lubricated blanks were extruded to a diameter of 0.39 in., their initial diameter determining the degree of reduction of cross section.

The effect of reduction of area on extrusion pressure is shown in Fig. 7, which clearly indicates that the pressure increases almost proportionally with reduction of area, and also with increase in tensile strength of the steel. When plotted into a double logarithmic system of coordinates, the average values for steels with carbon ranges of 0.08 to 0.12%, 0.12 to 0.27% and 0.45 to 0.50% lie on three parallel lines. These relationships determined in the extrusion of round steel blanks were confirmed by tests on tubular products.

Table IV — Dependence of Extrusion Pressure on Yield Point and Tensile Strength

Die Angle	Values From Tests on 11 Steels		
	Average	Max.	Min.
Ratio of Pressure to Lower Yield Point			
40°	3.9	4.5	3.5
90	4.4	5.2	4.1
126	5.1	5.8	4.7
180	6.5	6.8	6.1
Ratio of Pressure to Tensile Strength			
40	2.4	2.7	2.3
90	2.7	3.1	2.4
126	3.1	3.5	2.7
180	3.9	4.2	3.5

Table V — Effect of Reduction of Area on Notch Toughness

Steel	Notch Toughness in M-Kg. per Sq.Cm. for Given % of Reduction of Cross Section Area*						
	0%	20%	30%	40%	50%	60%	75%
No. 1	12.0	11.2	10.3	10.0	8.8	9.5	10.5
2	12.0	2.0	2.5	5.4	6.2	7.0	7.9
3	11.9	12.0	10.4	8.9	8.0	8.2	9.7
4	11.5	2.3	2.0	2.7	4.0	6.0	9.9
5	12.4	6.7	6.3	5.6	6.0	6.3	11.7
6	11.0	6.0	4.0	4.8	4.7	5.0	7.1
7	14.3	1.0	1.1	2.0	4.0	8.8	10.3
8	10.8	9.0	6.0	4.7	4.5	6.8	7.1
9	13.0	9.0	7.5	6.6	5.9	6.4	9.9
10	2.4	1.7	1.9	2.0	2.1	2.8	6.0
11	1.1	1.3	1.3	2.2	2.6	3.2	4.9

*Starting diameters were such that, after the various percentages of reduction, the extruded bar was 0.393 in. diameter.

Extrusion Pressure Needed

Values computed from these test results for ratios of extruding pressure to lower yield point and to tensile strength further confirm the previously mentioned observation that extruding pressure does not increase in proportion to tensile strength. From these experiments the following formula was derived: Required extruding pressure in psi. = (reduction of cross-sectional area in % − 10) × 0.054 × tensile strength in psi. of the steel.

Returning to Table V, a characteristic feature of the aluminum-bearing steels can be noted. The aluminum-free steels have the lowest impact values at small reductions of cross section, but these values increase rapidly as reduction becomes greater. Notch toughness of these aluminum-bearing steels (No. 1, 3, 5, 8 and 9) is much less affected by the degree of reduction; lowest impact values usually occur at about 50% reduction of cross section. After 75% reduction the impact values of almost all the steels closely approach, and may even surpass, the original values. Fractures of impact test bars show the formation of fibrous structure with increasing cold deformation, and this is evident even in steels which originally showed granular, cleavage-type fractures in the low range of cross-sectional reduction.

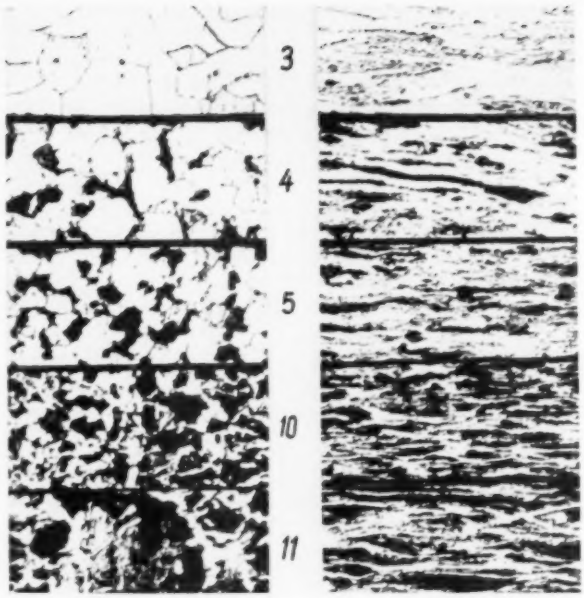
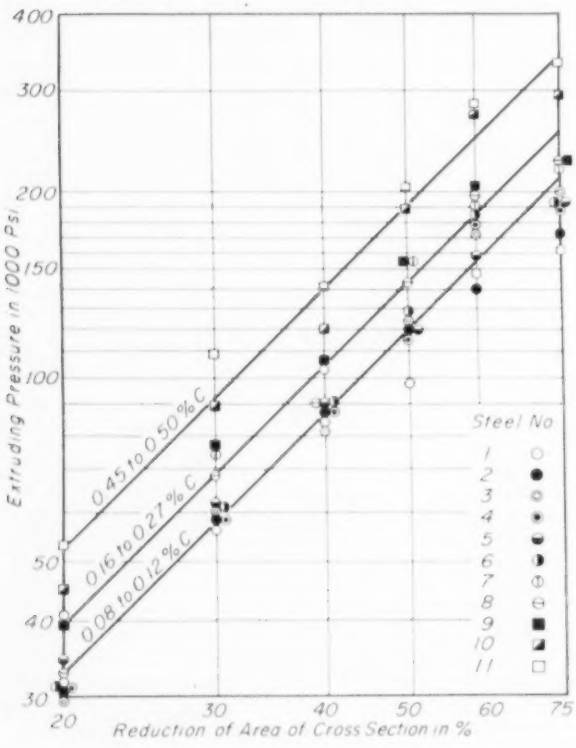


Fig. 8 – Microstructure of Five Steels of Increasing Carbon Content (See Table II) in the Original Normalized Condition, Left, and After Cold Extrusion With 75% Reduction of Area

Fig. 7 – Effect of Reduction of Cross-Sectional Area on Extrusion Pressure for Steels of Three Carbon Ranges. Diameter of bars 0.39 in.; die angle 126°; phosphate lubricant



Because of the pronounced elongation of the grain as a result of cold extrusion, the notched-bar impact resistance normal to the flow (transverse test) is naturally lower than in the longitudinal tests described above, but the difference is not as great as might be expected. The anisotropy of the metal crystallites causes pronounced differences in the degree of deformation of individual grains during cold extrusion. Figure 8 contrasts the structures of five steels from Table II with carbon varying from 0.05 to 0.50%, in the original normalized condition and after cold extrusion with 75% reduction in area. The ferrite grains are deformed the most, their resistance to deformation depending largely on the direction of the crystal axis relative to the direction of cold work.

FLOWABILITY AND FRACTURE TESTS

These investigations led to the conclusion that, under given conditions of cold deformation, the extrusion pressure depends upon the yield strength and tensile strength of the steels. In industrial extrusion, flowability of various heats of steels is also affected by heat treat-

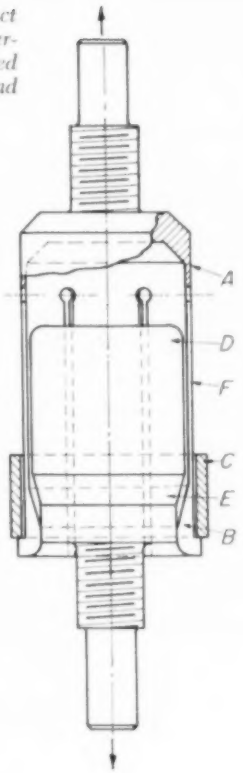


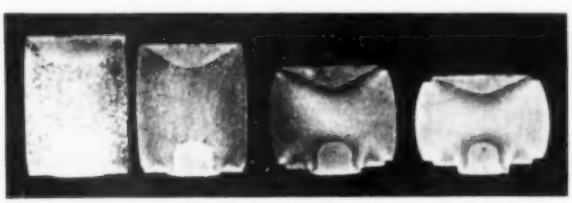
Fig. 10 – Apparatus for Ring Impact Test Devised by Pessl for Determining Behavior of Tubular Extruded Parts Under Internal Shock Load
A – Slotted expander
B – Mouth
C – Test piece
D – Plug
E – Tapered section
F – Slits

ment and structure. Hauttmann has suggested the following test for evaluating flowability: A cylindrically shaped test bar is placed over a base plate having a circular hole and subjected to compression. The hole should have carefully rounded edges and be half the diameter of the test cylinder. At various degrees of upsetting, the increase of the bar diameter and the depth of flow of material into the hole of the base plate are measured. Appropriate recording equipment follows the deformation of the sample bar as the test proceeds. Flowability is measured by the ratio of the increase in diameter to the depth of depression. Figure 9 shows a series of test pieces which have been compressed to varying degrees, sectioned, recrystallized at 1380° F. and etched. Grain coarsening indicates areas of critical cold deformation (12 to 20%) and furnishes interesting information regarding the mechanism of flow.

A simulated service test was developed by Pessl* for determining the impact resistance transverse to direction of flow of tubular products subjected to internal pressure. The equipment for this "ring impact tensile test" is shown in Fig. 10. A slotted expander A tapers into a mouth B at the lower end, and this has a flange which supports the ring-shaped test piece C. The plug D, also having a tapered section E, is inserted, and the test piece is slid over A. The threaded ends of expander and plug are then screwed into the hammer and crossbar of an Izod or Charpy impact testing machine. When the hammer swings through, the crossbar is caught by the stops provided for impact tension testing which are fastened to the lower part of the frame of the impact machine, thereby pulling the plug through the expander. Since the tapered sections of the two are moving in opposite directions, the mouth of the expander, and consequently the test piece, is widened to a certain degree.

Therefore, if the expansion is great enough to fracture the test piece, its elongation and the impact tensile energy that is absorbed can be determined. The results obtained from the ring impact test clearly indicate the existence of a boundary range above which plastic deformation occurs, as indicated by shearing fracture, and below which cleavage fractures are obtained.

Fig. 9 – Successive Stages in Cold Upsetting Test to Determine Flowability. Longitudinal sections of test pieces show depression of material into hole in base plate. Annealed at 1380° F. and etched



SUMMARY

The possibilities for using cold extrusion in the fabrication of steel products are manifold and new applications of the process are constantly being developed. Because of the relatively high tooling costs, the process is best suited to mass-production methods.

The advantages of cold extrusion of steel can be summarized as follows:

Saving of material and time because of fewer operations and less machining.

Conversion of low-strength steels to high-strength finished products because of the work hardening effect (strength may be as much as doubled).

Uninterrupted fiber flow resulting in greater load-carrying capacity.

Good surface finish and retention of tolerances within close limits.

Lower machinery investment and the utilization of less floor space.

*German Patent No. 690,495, Class 42k, Group 2002, March 15, 1940.

Tools, Lubricants and Steels for Cold Extrusion

By TOM BISHOP
Special European Correspondent
to Metal Progress

IT IS NOW almost 20 years since the first successful attempts to extrude steel were made in Germany, and during this time considerable developments have been made in America and Europe. An interesting two-day conference (organized by the Sheet and Strip Metal Users Technical Association) on cold extrusion of steel was held in London, England, in May 1953, to discuss all aspects of the subject, including press design, metallurgical considerations, metal lubrication, and other related factors. This report reviews the major points on some of the metallurgical problems involved.

Die Steels – E. Johnson of William Jessop and Sons Ltd., Sheffield, and E. Bishop of the British Standards Association group research center, while stating that it seems too early in the history of the cold extrusion process to decide finally what types of materials will be most suitable for the various parts, indicated the general trends in material used for extrusion dies. When the literature on cold extrusion is examined, it is found that a very wide variety of toolsteels has been used, including plain carbon, oil hardening nondistorting carbon-manganese, air hardening carbon-chromium, high speed steels, and even cemented carbides. A recent paper recommends the graphitic 2.8% tungsten steel "Graph-Tung" (1.5 C, 0.5 Mn, 0.65 Si, 0.5% Mo), on account of its antifriction properties. There is, however, comparatively little information as yet available on die life.

The types and compositions of the steels selected are listed in Table I. They are readily available and in regular use for various applications. All but one of these steels are rich in carbon. The basis of these steels is a hard martensitic matrix, for which at least a eutectoid carbon content is desirable. The common alloying elements are chromium, tungsten and vanadium, these being added to form carbides with a part of the carbon present.

REVIEW OF DIE STEELS

Not least among the difficulties in handling toolsteels is the manner in which the desired microstructure of carbides dispersed in a martensite matrix can be attained. The variety of compositions used is related to this problem, as will be seen as the steels are individually considered.

Steel No. 1, a plain-carbon steel, must be quenched very rapidly to produce martensite; it is, therefore, hardened in water or brine, and even so hardens only to a very shallow depth. The core is much softer, but has a useful degree of strength and toughness. The absence of alloys makes this a relatively inexpensive steel.

A carbon toolsteel can be greatly improved by the addition of vanadium, as in

Table I – Number, Type and Composition of Die Steels

No.	Type	Nominal Composition, %				
		C	Mn	Cr	V	W or Mo
1	1% carbon	1.1	0.25	–	–	–
2	1% carbon-vanadium	1.0	0.3	–	0.2	–
3	1¼ tungsten	1.25	0.3	0.3	–	1.3 W
4	5½ tungsten	1.6	0.3	0.6	–	5.5 W
5	5½ tungsten-vanadium	1.6	0.3	0.6	1.0	5.5 W
6	High-carbon chromium	1.0	0.4	1.45	–	–
7	High-carbon chromium	1.0	0.7	1.45	–	–
8	1½ tungsten-chromium	0.9	0.9	1.15	–	1.5 W
9	1¾ manganese	0.9	1.85	0.45	–	0.45 W
10	1¼ manganese	0.9	1.25	0.45	–	0.45 W
11	6¼ chrome-molybdenum	1.0	0.35	6.25	–	1.0 Mo
12	High-carbon, high-chromium	2.3	0.35	13.0	–	–
13	High-carbon, high-chromium	1.65	0.45	13.0	0.3	0.7 Mo
14	18-4-1 high speed	0.75	–	4.25	1.4	18.0 W
15	14-4-4 high speed	1.2	–	4.5	3.8	13.5 W
16	4¼ nickel-chromium-molybdenum (carburizing steel)	0.15	0.5	1.3*	–	0.3 Mo

*Plus 4.25% Ni

Steel No. 2. This steel is also very shallow hardening, but is easier to quench successfully and has a tougher core due to its smaller grain size. Steel No. 3 is the third type; the addition of chromium and tungsten introduces more carbides into the structure and these improve its wear resistance.

When larger amounts of chromium and tungsten are added, the steel becomes deeper hardening, to such an extent that with Steel No. 8, oil quenching can be used. Another advantage is its ability to resist distortion during hardening.

Steels No. 9 and 10 are similarly "nondistorting", but have somewhat lower chromium and tungsten and increased manganese contents. They are much deeper hardening than the previous steels; of the two, No. 9 is the more popular, although No. 10 is sometimes preferred because of its claimed higher toughness.

Steels No. 6 and 7 are somewhat simpler than those just considered. They consist essentially of a high-carbon steel with 1.5% Cr. Steel No. 6 still requires water hardening, but the high manganese content of No. 7 makes it capable of oil hardening up to larger sizes.

High-alloy steels will now be considered in two series, containing chromium and tungsten, respectively, as the major alloying element. Steel No. 11 contains 6.25% Cr and 1% Mo, and is thus very rich in chromium carbides which impart very high resistance to abrasion. This steel is air hardening in small sections and it is fairly tough.

Effect of Chromium and Tungsten

The limit in the chromium-rich toolsteels is reached in No. 12 with its 2.25% C and 13% Cr. Abrasion resistance is extremely high, but the shock resistance is relatively poor. The steel is difficult to machine and grind in the annealed condition, owing to the presence of large numbers of carbides. Many toolsteel users consider that No. 13, which contains less carbon and has small amounts of molybdenum and vanadium added, is an improvement in all respects.

Tungsten has little effect on the hardenability of steel, so that No. 4 (5.5% W) must still be water hardened. The presence of abundant tungsten carbides again confers high wear resistance on the steel.

Number 5, similar to the last, but with an addition of 1% V, is perhaps not usually considered as a die steel. The vanadium, however, further increases its wear resistance, and it is for this reason worthy of inclusion.

Steels No. 14 and 15 are tungsten-rich high speed steels. Apart from the fact that they are stated in the literature to be useful for cold extrusion dies, they should be considered for a reason which until now has not been mentioned. It is known that extruded parts often leave the presses quite hot; temperatures up to 570° F. have been quoted. The actual surface temperatures reached at the die faces are not known, but the majority of steels considered so far are likely to soften very quickly due to

Table II — Heat Treatment and Other Data

Steel No.	Hardening, °F.	Quenching Medium	Tempering, °F.	Rockwell Hardness	Ac_1 Temp., °F.	M_s Temp., °F.	Type S-Curve*	Hardenability	Abrasion Resistance
1	1435	W or B	355	C-62-64	1328	430	I	Shallow	Low
2	1455	W	390	62-64	1328	430	I	Shallow	Low
3	1470	W	390	62-64	1365	355	I	Shallow	Low
4	1500	W	390	61-63	1365	390	II	Medium	Medium
5	1500	W	390	61-63	1365	390	II	Medium	Medium
6	1500	W	390	62-64	1345	390	II	Medium	Low
7	1545	O	390	62-64	1345	390	II	Medium	Low
8	1500	O	390	62-64	1345	390	II	Medium	Low
9	1455	O	390	62-64	1310	340	II	Deep	Low
10	1435	O	390	62-64	1328	375	II	Medium-deep	Low
11	1780	O	300-1020	62-45	1435	430	III	Deep	Medium to high
12	1780	O	390-930	62-55	1470	375	III	Deep	Very high
13	1870	O or A	390-930	61-55	1455	390	III	Very deep	Very high
14	2370	O or A	1020 DT	62-64	1490	430	IV	Deep	High
15	2335	O	1020 DT	62-65	1490	355	IV	Deep	Very high
16	1420	O	355-390	56	1200	660	III	Deep	Low to medium

B = Brine.
W = Water.
O = Oil.
A = Air.
DT = Double temper.
Ac_1 = The change point on heating.
M_s = The martensite start point on cooling.
* = See Fig. 1 *(a)* to *(d)*.

tempering if heated. The high tungsten content of the martensitic matrix of high speed steels raises the tempering temperature to much higher than normal limits. This may explain the very high wear resistance of these steels under what is normally considered room-temperature operation.

Number 14 is the well-known 18-4-1 high speed steel, whereas No. 15 contains less tungsten and more vanadium and has the higher wear resistance of the two. There is perhaps no need to point out that both these steels require a double tempering treatment to induce full secondary hardening.

The principle of a hard, wear resisting case supported by a softer but strong and tough core, which is met in the shallow hardening tool-steels, is also exemplified in the next steel. Number 16, the well-known 4.5% Ni-Cr-Mo case hardening steel, gives a carburized case having a Rockwell hardness of C-56; the ductility and toughness of the core are of a very high order.

Table II gives details of the recommended heat treatments for the selected steels. In Fig. 1 are given typical isothermal transformation diagrams for Steels No. 1, 9, 11 and 15 respectively. The other steels all have diagrams similar to one of these four types, as indicated in Table II.

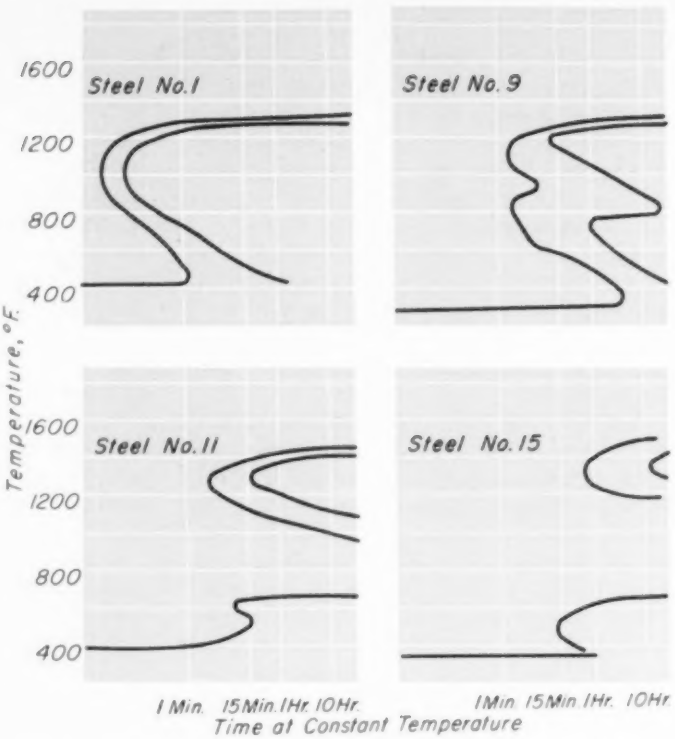


Fig. 1 – Isothermal Transformation Diagrams of Four Typical Steels

Steel No. 1	*1.1% C*	*Type I*
Steel No. 9	*1.85% Mn-Cr-W*	*Type II*
Steel No. 11	*6.25% Cr-Mo*	*Type III*
Steel No. 15	*13.5% W-Cr-V*	*Type IV*

Other Steels and Materials – As mentioned previously, graphitic steels have been used. Graph-Tung (containing 0.3% graphite after suitable heat treatment) is water hardening and of fairly shallow hardenability. Graphitic steels are stated to have a high resistance to wear and good frictional properties without much of a tendency for pickup and scoring. They are free-machining and tougher than similar steels when hardened.

Another steel, WEX 491 (an experimental steel designation of William Jessop & Sons Ltd.), contains 1.0 C, 2.0 Mn, 2.0 Cr, and 1% Mo. This is an oil hardening steel which, in addition to being a useful die steel in

Table III – Classification of Steels Suitable for Cold Extrusion

Designation	Mode of Manufacture	Composition, %				
		C	Si	Mn	P	S
Steel I	Siemens-Martin Steel, killed	0.09	0.07	0.28	0.012	0.02
Steel II	Siemens-Martin Steel, non-killed	0.05	–	0.25	0.011	0.016
Steel III	Siemens-Martin Steel, killed	0.16	0.28	0.51	0.025	0.016
Steel IV	As I	0.30	0.27	0.58	0.017	0.018
Steel V	As I	0.47	0.26	0.60	0.014	0.013
Steel VI	As I	0.12	0.29	0.38	0.022	0.040
Steel VII	As I	0.39	0.29	0.66	0.026	0.020
Steel VIII	Thomas Steel, non-killed	0.05	–	0.32	0.045	0.027
Steel IX	Thomas Steel, killed	0.28	0.25	0.53	0.064	0.029
Steel X	Siemens-Martin Steel, killed with Aluminium*	0.12	0.07	0.204	0.016	0.025
Steel XI	Chromium Steel EC 60†	0.11	0.28	0.36	0.020	0.024

*Plus 0.09 Al, 0.155 Cu. †Plus 0.58 Cr, 0.58 Cu.

its own right, is also useful for composite carbide-steel dies, as final heat treatment from the carbide brazing temperatures is possible. It has a fairly good abrasion resistance and deep hardenability.

Cemented carbides of the tungsten carbide-cobalt type are also relevant. (EDITOR'S NOTE: A summary of recently acquired knowledge of these is given on p. 166.) They are hard (Vickers hardness about 1500), fairly brittle, and do not require final heat treatment. However, they are expensive, particularly in large die-ring sizes.

Of the various treatments other than carburizing which alter the surface properties of dies, nitriding and chromium plating are most useful. R. Oettel, describing recent German work, has discussed carburizing steels which are so adjusted in alloy content that free graphite is formed in the case. Surface-graphitized dies may be of considerable interest, as they would combine the good case and core properties of alloy carburizing steels together with the advantages of wear resistance and antifriction properties. It is considered that there is a large field which can be usefully investigated here, since there are other surface treatments which, though more difficult to produce, may help to reduce friction and pickup when lubrication is poor.

GENERAL COMMENTS

No one material for die steels is superior in all respects, but the choice, as in deep drawing, pressing and similar die applications, depends on factors such as die design, pressures employed, and efficiency of lubrication – these being the most important. As already mentioned, different parts of the tool assembly may be made of different materials so as to obtain specific benefits. A choice that seems to warrant consideration would be a nitrided steel of high carbon and high chromium for the punch, and a die of manganese, nondistorting steel shrunk into a nickel-chromium steel bolster, particularly for back-extrusion assemblies. It should be remembered that the cost of the steel is only a fraction of the cost of making a die, and hence the use of the more expensive steels is economical if die life is improved. One manner in which cost can be reduced is by the use of composite dies, as replacement of worn or broken parts is less expensive.

During his review of continental work on cold extrusion of steel, H. Fischer, of Kabel und Metallwerke Neumeyer A. G., revealed the compositions and mechanical properties of German drawing steels (see Tables III and IV). The most suitable material is steel in the fully annealed or spheroidized condition with an optimum grain size of A.S.T.M. 7 to 9.

For lubricant carriers, Fischer states that layers of zinc or manganese phosphate which have been applied by a dipping process have proved particularly suitable. These layers must be thicker than the 10 to 15 μ applied for protection against corrosion or for the surface treatment for drawing parts from this sheet, or for thin tubes. Lubricants containing a fatty acid, like rape oil or tallow, are mainly used; also their lubricity can be increased by sulphur compounds. Others are palm oil and soaps in aqueous solution. Soap precipitated from aqueous solution, which is allowed to dry on the surface, has also been used.

The surface treatment of tools requires great care during grinding and polishing or lapping. The latter is particularly good if it can be applied in the direction of the material flow because this diminishes the unfavorable action of transverse grinding grooves.

Further papers during the symposium centered on the relative merits of mechanical or hydraulic presses for the cold extrusion of steel. T. F. Massey, of Wilkins & Mitchell Ltd. (England), concluded that while it is difficult to generalize, the mechanical press is probably the best proposition, both technically and economically, for pressures of 4000 to 5000 tons. Above this range, practical considerations would probably favor the hydraulic press.

Table IV – Physical Data of Steels Suitable for Cold Extrusion

DESIGNATION	TENSILE STRENGTH, PSI.*	STRETCH LIMIT, PSI.*	ELONGATION AT BREAK, %	REDUCTION OF AREA, %
Steel I	53.2	36.0	33	68
Steel II	51.4	34.1	35	72
Steel III	61.8	38.6	28	56
Steel IV	67.4	44.4	27	47
Steel V	77.3	51.2	21	33
Steel VI	54.7	37.2	32	64
Steel VII	69.8	41.8	30	51
Steel VIII	54.1	37.3	32	65
Steel IX	68.4	44.2	22	48
Steel X	50.3	34.5	34	68
Steel XI	59.7	41.6	30	60

*Values in thousands.

By J. FIELD, Metallurgical Supervisor
Bethlehem Plant
Bethlehem Steel Co.

overheating has occurred in a sufficient degree.

3. The mechanics by which overheating occurs have not been positively established. Of the various explanations proposed, the most promising appears to be that of A. Preece and co-authors which suggests that overheating results from diffusion processes within the austenite grains with subsequent grain boundary precipitation during cooling through the overheating range. This hypothesis is based on findings which indicate that the rate of cooling has an important influence on the development of the overheated structure.

Effect of Boron on the Overheating Temperature of Steel

INTERGRANULAR or faceted fractures are frequently observed on steels subjected to hot forming temperatures and subsequently refined by a quench and temper treatment. The presence of these facets is regarded as an indication that the steel has been overheated. Since an overheated structure impairs the heat treated physical properties, those concerned with the hot working of steel are ever conscious of the need for careful selection and control of the heating temperature. The problem has received considerable attention both here and abroad and the results of extensive investigations[1, 3]* have shown that:

1. The facets are best revealed by quenching and tempering the overheated steel prior to fracturing. In this condition fracture occurs at the boundaries of the facets, resulting in a contrast in appearance of the faceted grain and the more fibrous matrix.

2. The ductility, as measured by impact tests and by the reduction of area and elongation of tensile tests, is adversely affected if overheating has occurred in a sufficient degree.

3. The mechanics by which overheating occurs have not been positively established. Of the various explanations proposed, the most promising appears to be that of A. Preece and co-authors which suggests that overheating results from diffusion processes within the austenite grains with subsequent grain boundary precipitation during cooling through the overheating range. This hypothesis is based on findings which indicate that the rate of cooling has an important influence on the development of the overheated structure.

4. Possible curative treatments for overheated structure include high-temperature normalizing, while preventive treatments involve controlling the cooling rate through the overheating range from the forging temperature.

The work described in this paper was prompted by finding that an S.A.E. 1045 steel to which 0.003% boron had been added for increased hardenability showed evidence of overheating at forging temperatures previously found satisfactory for 1045 steel without boron. Typical fractures of the two steels heated to 2200° F. for 1 hr.† are shown in Fig. 1.

This behavior was somewhat unexpected in view of the prevailing belief that boron steels could be handled in forging in the same manner as steels without boron. However, as shown by the present investigation, comparing the effects of two boron ferro-alloys commonly used in production of boron steels, the overheating characteristics of a steel are markedly affected by the type of boron ferro-alloy used as the addition agent.

MELTING AND SELECTING OF MATERIAL

The material selected for study represented seven commercial basic openhearth heats of 1045 steel. Three were modified with boron

*See references on p. 83.

†In all results of tests reported in this article, a conditioning treatment for revealing facets followed the high-temperature treatment. The conditioning treatment consisted of normalizing, quenching and tempering to a hardness range of Brinell 321 to 341.

Table I – Chemical Analysis of Heats Used in Study

Ingots	Addition	Composition, %								
		C	Mn	Si	Ni	Cr	Mo	B	Ti	Zr
No. 1	None	0.44	0.76	0.20	0.15	0.18	0.04	—	—	—
No. 2	12% boron alloy	0.44	0.88	0.21	0.10	0.11	0.02	0.0035	0.004	—
No. 3	12% boron alloy	0.43	0.72	0.23	0.13	0.12	0.02	0.0027	0.004	—
No. 4	12% boron alloy	0.48	0.83	0.22	0.06	0.16	0.03	0.0021	0.004	—
No. 5	Special alloy*	0.48	0.93	0.29	0.11	0.18	0.04	0.0007	0.060	Trace
No. 6	Special alloy	0.45	0.80	0.24	0.10	0.17	0.03	0.0007	0.060	Trace
No. 7	Special alloy	0.47	0.88	0.25	0.11	0.19	0.02	0.0007	0.060	Trace
No. 7A	Special alloy + 12% boron alloy	0.47	0.87	0.24	0.11	0.17	0.02	0.0039	0.060	Trace

*Vendor's analysis for special alloy: Al 13, Ti 20, Zr 4, Mn 8, B 0.50, Si 5%.

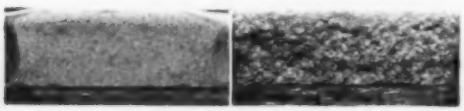


Fig. 1 – Fractures of 1045 Steel Treated at 2200° F. (Actual Size). Steel on the left had no boron; the steel on the right contained 0.003% boron, which was added as 12% boron alloy

which was added in the form of a simple 12% boron alloy, while three others were melted with boron added in the form of a complex ferro-alloy containing aluminum, titanium and zirconium in addition to boron and hereafter referred to as special alloy. The first heat for comparative purposes contained no boron alloy or special alloy addition. All the heats were melted with normal aluminum additions for grain size control. Addition of the 12% boron alloy or special alloy was made in the ladle immediately following the aluminum addition. The 12% boron alloy was added in an amount to provide 0.003% boron, while the special alloy addition was made in accordance with the vendor's recommendation of 4 lb. per ton (amounting to an addition of 0.001% boron). In order to provide a steel that was treated with the special alloy and have it contain 0.003% boron, a final ingot of a special alloy heat was treated with a supplementary addition of 12% boron alloy. Samples for the investigation were all selected from rolled billets or bars.

The chemical analyses determined on the heats selected for this investigation and the vendor's reported analysis for the special alloy are shown in Table I. In addition to the common elements, the 12% boron alloy and special alloy heats were analyzed spectrographically for boron, titanium and zirconium.

IMPACT AND TENSILE TESTS

It had been found from prior work that the use of an oversize impact specimen afforded a convenient means of studying the overheating characteristics of a steel. In the first place, the test insures that the fractures are obtained on specimens broken in a uniform manner; secondly, the drop in impact resistance is in itself an indication of the degree of overheating. It is desirable in this connection to use the largest specimen that can be broken within the capacity of the testing machine in order to provide large fractured areas for visual examination. Equally important is the fact that the very low impact resistance obtained with overheated structures on smaller conventional impact specimens makes it difficult to evaluate the results. A specimen measuring 1.375 in. wide, 0.562 in. thick and 5 in. long provided a convenient size for use in the impact machine (600-lb. capacity) available for this investigation. A 45° V-notch, 0.112 in. deep and having a 0.010-in. radius, was machined 1.1 in. from the end of the specimen.

Longitudinal test blanks 1 x 2 x 6 in. were cut from the as-rolled billet and bar stock. These were heated at 50° F. intervals from 2000 through 2600° F., held 1 hr. at temperature, and air cooled. Impact specimens were machined slightly oversize (0.030 in.) of the finished dimensions of 0.562 x 1.375 in. and then normalized by air cooling from 1650° F. The heats with the 12% boron alloy and special alloy additions were then oil quenched from 1550° F. and tempered to a hardness between Brinell 321 and 341. The regular 1045 steel (containing no boron) had to be water quenched to obtain the desired hardness. After the treatment, the specimens were finish machined to 0.562 x 1.375 x 5 in., and the V-notch

Ingot No.:	1	2	3	4	5	6	7	7A
Additions:	None	12% Boron Alloy	12% Boron Alloy	12% Boron Alloy	Special Alloy	Special Alloy	Special Alloy	Special Alloy +12% Boron
As-Rolled	12.8	16.4	15.0	13.5	14.2	14.2	16.4	15.0
2000° F.	13.5	12.8	14.2	15.0	13.5	14.2	15.7	15.0
2050	15.0	14.2	13.5	14.2	14.2	15.0	14.2	15.0
2100	14.2	15.0	10.7	13.5	15.0	15.1	15.0	14.2
2150	15.0	15.0	9.6	12.1	15.0	14.2	15.0	15.0
2200	15.0	13.5	9.3	6.4	15.0	14.2	15.0	15.0
2250	14.2	10.7	7.9	7.9	15.0	14.2	15.0	15.0
2300	15.0	7.1	7.9	6.4	15.7	16.4	15.1	15.0
2350	15.7	5.7	8.6	5.7	15.0	15.0	15.1	15.7
2400	14.2	7.1	8.6	6.4	15.7	15.0	15.1	14.2
2450	14.2	7.9	9.3	7.1	14.2	12.8	16.4	14.2
2500	15.0	5.7	9.3	6.4	13.5	15.0	15.7	10.7
2550	7.1	4.3	1.4	1.4	14.2	1.4	5.7	10.7
2600	4.9	2.9	1.4	3.6	5.0	1.4	6.4	1.4

Table II – Effect of Heating Temperatures on Impact Resistance of Boron-Modified S.A.E. 1045

Heating Temp., °F.	Impact Resistance, Ft-Lb. for Each Ingot No. and Addition Agent Shown							
	1 None	2 12% Boron Alloy	3 12% Boron Alloy	4 12% Boron Alloy	5 Special Alloy	6 Special Alloy	7 Special Alloy	7A Special Plus 12% Boron
None	260	285	220	230	250	320	295	295
2000	270	240	200	230	265	345	320	200
2050	265	255	190	210	275	375	310	145
2100	280	310	130	215	290	400	320	165
2150	290	245	100	150	280	345	320	170
2200	280	110	85	90	275	320	325	180
2250	300	135	90	80	285	350	320	170
2300	300	60	60	60	290	400	330	130
2350	315	60	80	70	275	320	330	170
2400	310	60	80	80	290	335	340	150
2450	210	70	105	80	295	250	340	140
2500	290	60	40	70	265	80	325	120
2550	100	30	45	25	285	100	180	155
2600	65	25	60	85	245	45	30	45

was made. For comparative purposes, an additional test specimen was similarly prepared from each heat by normalizing, quenching and tempering the as-rolled stock (no high-temperature treatment). The results of impact tests are reported in Table II, while the fractured surfaces of the specimens are shown in Fig. 2.

Tensile specimens of 0.375 in. diameter and 1.5 in. gage length were machined from the broken impact specimens. The percentage of elongation obtained for each sample is shown in Fig. 2.

END-QUENCH HARDENABILITY

The hardenability of each heat was determined by means of the standard Jominy end-quench test. The specimens were machined from bars forged to 1.25-in. diameter and normalized at 1650° F., and were end-quenched from 1550° F. Hardnesses and cooling rates for the specimens are plotted in Fig. 3.

DISCUSSION OF RESULTS

It is readily evident from a comparison of the fractures that the normal overheating characteristics of a 1045 steel are markedly altered by the presence of 0.003% boron added in the form of 12% boron alloy. It will be noted that the incipient overheating temperature of 2550° F. obtained on the 1045 steel without boron drops to a range of 2050 to 2200° F. with the addition of 0.003% boron in the form of 12% boron alloy.

Fig. 2 – Comparison of Fracture Surfaces and Elongations of S.A.E. 1045 Without Boron, With 12% Boron Alloy, and With Special Alloy Treatments. All specimens quenched from 1550° F.

The overheating characteristics of the steels with special alloy differed considerably from those observed in the steels with 12% boron alloy; the former remained fine-grained on fracture tests after heating to temperatures well above those at which overheating occurred on the steels treated with 12% boron alloy. In this respect they appear to be quite similar to the normal 1045 steel, and for samples from heat No. 5 show even finer fractures than the normal 1045 steel. Apparently this behavior is due to the presence in the special alloy of *(a)* titanium and zirconium, *(b)* a relatively low boron content or *(c)* the combined effect of *(a)* and *(b)*. The fact that the presence of titanium is effective in inhibiting overheating in boron steels has been verified on additional heats treated with another boron ferro-alloy in conjunction with a supplementary addition of titanium.

The ingot treated with special alloy No. 7A, to which an addition of 12% boron alloy was made, aiming for 0.003% boron, showed a tendency toward overheated fractures at low temperatures, although to a lesser degree than special alloy heats 2, 3, and 4. It should be noted that the boron content of this material was 0.0039%. It is possible that the amount of titanium and zirconium introduced by the addition of 4 lb. per ton of special alloy was insufficient to overcome entirely the effect of this relatively high boron content.

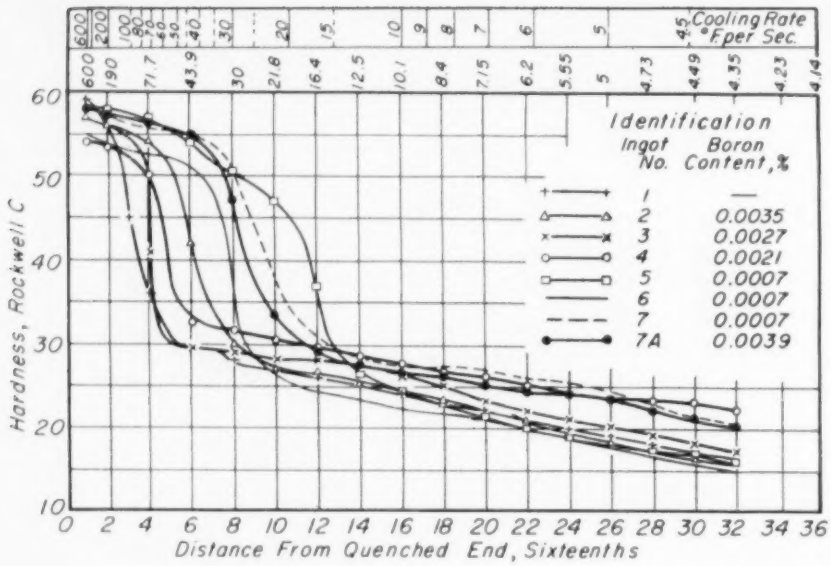


Fig. 3 – Hardenability Curves for S.A.E. 1045 Without Boron (Ingot No. 1), Treated With 12% Boron Alloy (Ingots No. 2, 3, and 4), With Special Alloy (Ingots No. 5, 6, and 7) and With Special Alloy Plus 12% Boron Alloy (Ingot No. 7A)

The impact test results, as well as the elongation and reduction of area obtained on the tensile tests, indicate with few exceptions a sharp decrease in ductility at the temperatures which produce large grains or facets. In the special alloy heat No. 5, no overheating was observed over the full range of the temperatures investigated, and consequently no sharp drop in ductility was found until it was heated to 2600° F. The tendency toward erratic impact and tensile results often found within the temperature series can be traced to variations in hardness within the range of Brinell 321 to 341, and also to mixed or duplex grains produced within a specimen.

It will be observed that many fractures do not reveal increasing grain size with increasing temperature. For example, the specimens heated at 2600° F. do not always appear coarser than overheated specimens heated at a lower temperature. On etching with hot acid the specimens heated at 2600° F., evidence of burning (presence of voids about the grain boundaries) was found. It is probable that the fusion of the grain boundaries accompanying this burning masks the true grain structure on a fracture test.

Since boron is added to steel to increase its hardenability, it is of interest to compare the end-quench hardenability resulting from the small amount of boron remaining after additions of the special alloy and the 0.003% boron addition made as 12% boron alloy. Special alloy heat No. 7 and ingot No. 7A offer a direct comparison for this purpose. It will be noted from Fig. 3 that the end-quench hardenability results of the two steels are comparable and indicate that the maximum effect to be de-

Table III – Effect of Boron Additions on Tensile Properties of S.A.E. 1045

Ingot No.	Heating Temp. (°F.)	Yield (M Psi.)	Ultimate (M Psi.)	Elong. (%)	R. A. (%)
1	As-rolled	151	163	12.8	51.0
	2000 to 2500	141 to 153	158 to 166	13.5 to 15.7	51.0 to 54.4
	2600	145	153	4.9	14.5
2*	As-rolled	130	157	16.4	54.1
	2000 to 2200	127 to 140	156 to 167	12.8 to 15.0	47.3 to 52.1
	2600	142	166	2.9	4.9
3	As-rolled	144	163	15.0	51.6
	2000 to 2050	140	160	13.8	48.8
	2500	144	162	9.3	26.0
	2600	126	146	1.4	3.3
4	As-rolled	149	169	13.5	50.4
	2000 to 2150	142 to 150	164 to 170	12.1 to 15.0	44.1 to 52.1
	2600	142	164	3.6	6.0
5†	As-rolled	144	166	14.2	52.5
	2000 to 2550	139 to 153	156 to 165	13.5 to 15.7	48.2 to 54.8
	2600	152	163	5.0	10.9
6	As-rolled	147	166	14.2	55.6
	2000 to 2500	120 to 165	153 to 177	13.5 to 16.4	52.9 to 59.2
	2600	142	157	1.4	8.2
7	As-rolled	142	157	16.4	53.3
	2000 to 2500	136 to 145	158 to 162	14.2 to 16.4	47.4 to 57.8
	2600	145	160	6.4	5.5
7A‡	As-rolled	142	157	15.0	47.8
	2000 to 2450	139 to 146	157 to 160	14.2 to 15.7	47.0 to 51.0
	2600	147	149	1.4	3.8

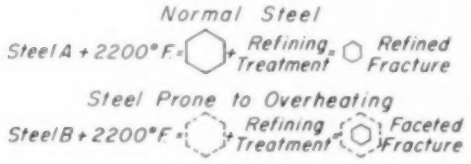
*Treated with 12% B alloy. †Treated with special alloy.
‡Treated with special alloy plus 12% B alloy.

rived from boron is obtained with the small amount (0.0007%) added by the special alloy. The increase in hardenability obtained with the special alloy treatment should not, however, be attributed entirely to boron, for apparently the titanium and zirconium present also produce a measurable effect.

There remains for consideration the cause of the pronounced lowering of the overheating temperature obtained with the additions of 12% boron alloy. In this connection, similar types of fracture have been found on cast steels, as reported by Lorig[6, 7]. In these, the brittle fractures have been associated with the precipitation of a brittle grain-boundary constituent – possibly aluminum nitride – in the regions formerly occupied by the boundaries of the primary austenite grains.

It is conceivable that in the overheated steels containing boron, a boron nitride constituent might be formed and precipitated at the austenite boundaries during the heating or cooling from the overheating range. The effectiveness of titanium and zirconium in preventing the brittle fractures might then be due to the suppression of the boron nitride constituent in favor of nitrides of zirconium and titanium. On this assumption, the mechanism by which overheating occurs in one steel and not in another can be shown schematically in Fig. 4 by considering the changes occurring in single crystals during the heating at high temperatures and subsequent refining and fracturing.

Fig. 4 – Schematic Representation of Why Overheating Occurs in One Steel and not in Another. Dotted line for Steel B represents formation of grain boundary constituent. After refining, fracture occurs through the boundary constituent



It is hoped that further investigation as to the exact identity of the boron constituent and the role of nitride-forming elements will prove of value in explaining the unusual overheating characteristics of steels made with 12% boron alloy additions.

CONCLUSIONS

1. The addition of 0.003% boron in the form of 12% boron alloy lowers the temperature at which overheating normally occurs in S.A.E. 1045 steel.

2. The addition of boron in the form of a special alloy addition agent does not affect the normal overheating properties of 1045 steel.

3. The addition of 0.003% boron by combined additions of the special alloy and 12% boron alloy results in the occurrence of facets at low temperatures, but to a lesser degree than are obtained with only the boron alloy addition.

4. The special alloy in amounts normally added does not lower the overheating temperature because of *(a)* the presence of zirconium and titanium, *(b)* the low amount of boron present or *(c)* the combined effect of *(a)* and *(b)*.

5. The occurrence of overheating lowers the ductility as measured by impact tests and by values for elongation and reduction of area in tensile tests.

Since an investigation of all of the numerous boron ferro-alloys was beyond the practical scope of this investigation, the conclusions stated above apply solely to two of a number of boron ferro-alloys commonly used in the production of boron steels. No implication is therefore intended regarding the effectiveness of other boron ferro-alloys or of modified practices in which the 12% boron alloy might be added in less than the recommended amounts or in combination with other elements.

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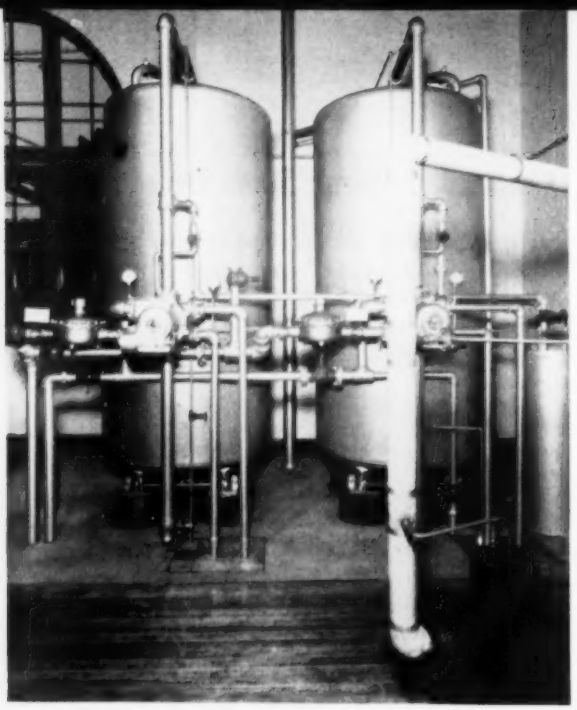


Fig. 1 – Cost Savings and Recovery of Critical Materials Are Made Possible With This Installation. Tank at left is the Permutit Q unit, at right is Permutit S tank. These two ion exchange units, of identical construction, are fabricated from corrosion resistant materials. Piping is also resistant to chromic acid. Solutions to be treated are introduced by the ion pumps and regenerant solutions are made up in the corrosion resistant tanks

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Plating Waste Treatment*

TREATMENT of electroplating rinse waters by ion exchange has been one of the most attractive methods considered in recent years for the recovery of electroplating wastes. Simultaneously, it helps solve a very serious problem of water pollution.

The most successful of the ion exchange processes applied has been the use of cation and anion exchangers in the recovery of chromic acid. (This was discussed at the 7th Purdue Industrial Waste Conference by the present author and several others.) There are really two separate ion exchange processes. One is the use of a cation exchanger to remove metallic cations from strong chromic acid solutions, such as are used for bright dipping, stripping, chromium plating, and chromic acid anodizing. The second is the use of an anion exchanger in series with a cation exchanger to recover the chromic acid from the rinse solutions following the above treatments. The rinse water may be reused virtually indefinitely and the chromic acid is eventually returned to the treatment bath.

Since the announcement of the cation exchange process several years ago, this process has developed rapidly, and there are now more than a dozen large plants throughout the country applying either all or a part of this process successfully. In this connection, we can report that it is now feasible to remove metallic cations from chromic acid solutions all the way up to the 40% concentration by cation exchange. Whether for any given installation this is economically attractive depends upon the over-all layout and scale of operation. The anion exchange process has recently been extended to the treatment of mixed chromate rinse water.

A process for the recovery of cyanide from cyanide plating rinse baths very similar in operation to the chromate rinse recovery process has been developed under one of the research projects of the American Electroplaters' Society. In essence, the process consists of passing all of the rinse water through a demineralizer to remove the metal cations, cyanide anions and complex cyanide ions, and then either sending the water to waste or back for further rinsing purposes. Then, during regeneration, caustic soda is introduced to the anion exchanger where its hydroxyl anions replace the cyanide ions from the resin. This solution then goes to the cation exchanger where the high concentration of caustic and cyanide dissolves off or regenerates off the heavy metal cations. The effluent then is a solution generally similar to a cyanide plating

*A paper presented before the 8th Purdue Industrial Waste Conference, Purdue University, Lafayette, Ind., May 4 to 6, 1953.

solution except of lower concentration and higher alkalinity. As far as known, this process is not as yet in large-scale usage.

The two processes described above, and a cation exchange process for recovery of metals from acid, copper or nickel rinse water, although very useful where the circumstances warrant them, have not overcome by any means all of the difficulties associated with pollution by plating rinse waters. They are economically most attractive in plants where relatively few kinds of plating are performed and these are performed on a large scale. They also depend for operation on the possibility of isolating one rinse water from another before there can be cross-contamination. Thus, where a single rinse bath is used to rinse following several plating baths, or common floor drains are installed, these processes cannot be applied. With most chromate baths, the recovered chromate may be returned directly to a save-rinse tank or evaporated for return to plating tank; in the case of cyanide baths, some anions, notably carbonate, build up in the rinse waters and it is not particularly attractive to return these to the plating tank. In many situations, the amount of water associated with the recovered plating salts is greater than can be put directly into the plating tank; therefore some evaporating process must be relied upon also.

The most generally encountered circumstances in the industry are almost invariably the direct opposite of the conditions mentioned above. Most electroplating shops contain a large variety of tanks of various sizes and do a wide assortment of plating operations. In a job plating shop it is difficult, if not impossible, to predict what a given tank will be doing next, and hence it is hard to justify installation of large and comparatively costly recovery equipment for a process which may not be in operation very long. Only in rather large plating operations has it been found that the value of the recovered chemicals more than offsets the amortization of the equipment plus the operating cost for the recovery process. In small operations, the labor cost may be considered excessive. This discussion describes a new water recovery process adaptable to small plants or large plants doing a variety of work.

Limitations for Job Shops

Demineralization of all rinse water, or at least final rinse waters in plating shops, has been proved on innumerable occasions to be worth-while. Demineralization generally decreases greatly the amount of rejects, eliminates or reduces sharply the amount of handling and buffing to remove stains and water spots, improves the corrosion resistance of the finished work, and for many operations improves the appearance of the work. This demineralized rinse water, after use, then needs treatment to render it nontoxic and thus the same water is generally treated twice at considerable cost for equipment and chemicals. It is quite generally found that the amount of plating salts picked up by a demineralized water when it is used for rinsing is less than the total electrolyte content of the raw water. Thus, close consideration of these factors makes attractive a combination water and waste treatment process. Several plants are now in operation using recycled plating rinse water as the feed to a demineralizer.

A very good typical installation employing this water recovery process is in operation in the plant of a Canadian manufacturer of aviation instruments. As yet, no waste treatment is in operation, as the authorities have not prescribed any standards, but the plant can be readily employed for such waste treatment. The chief reasons why a recirculated plating water process was resorted to were the shortage of water and the poor quality of the water available. As presently operated, water is recirculated at a flow rate of approximately 60 gal. per min. and picks up approximately 75 parts per million of electrolytes in passing through the plating shop. The raw water was available at a maximum flow rate less than 60 gal. per min., and contained approximately 600 parts per million of electrolytes. Thus, treatment of the recycled stream is considerably less expensive than comparable treatment of the raw water. It has also been found that the recirculated water has a higher temperature than the raw water, during most of the year, and hence does a more satisfactory rinsing job. This plant is equipped to do chromic and sulphuric acid anodizing, black dyeing, nickel, copper, zinc, cadmium, chromium and several other types of plating.

Figure 2 illustrates a complete operation of a combined water demineralization and waste treatment plant. All of the plating rinse water is collected in a storage tank and is pumped through a cation and an anion exchanger in series. It is necessary in some locations to install a cooler as well if there are a considerable number of hot rinse baths in the circuit. Then the water goes to a demineralized water storage tank from which it is sent back to the plating shop as demanded. For continuous

Purified Waste for Make-Up

operation, it is possible to provide either two demineralizing pairs, or sufficient demineralized water storage to provide water during the regeneration period. When the demineralizer becomes exhausted, the units are regenerated in the normal manner with sulphuric acid and caustic soda, except that the effluent, instead of being sent directly to waste, is sent to acid waste treatment and alkaline waste treatment tanks, respectively. The alkaline waste treatment tank contains a considerable amount of free alkali, and hence is ready for chlorination or other accepted techniques for the oxidation of cyanide under alkaline conditions. The oxidizing agent is fed to a recirculating stream until the cyanide is destroyed. Then the entire contents of this tank are pumped into the acid waste treatment tank.

Conditions in the plating operation are generally such that a quantity of cations equal to or greater than the quantity of anions appears in the rinse water, and since cation exchange resin regeneration is somewhat less efficient than anion exchange resin regeneration, a greater quantity of acid than alkali will be sent to the acid waste treatment tank. Therefore, after mixing of the two solutions, the contents of this tank will still be acid, and thus will be ready for the feeding of a reducing solution to destroy the chromate. This reducing solution is also fed into a recirculated water stream. When the chromate is all destroyed, caustic soda or lime may be fed to neutralize the free acid and precipitate all the metallic hydroxides. Then the contents of this tank are allowed to settle and the supernatant liquid sent to waste. The sludge is sent to a lagoon or sludge filter.

This process provides demineralized water for all the plating shop and recycles more than 90% of this water. Thus, it can be used where water is scarce or of poor quality.

The waste treatment processes as such are only operated upon the effluent from the ion exchange unit, so that they are more or less independent of the concentrations of ions, or the relative analysis of ions in the rinse water. Consequently, reactions in these waste treatment steps will be very reproducible from day to day, and the treatment cost will be a function only of the amount of dragout in the plating shop and not of the water flow rate. Water conservation in a plating shop, which is always very difficult to achieve, becomes less necessary, since the only cost of the added circulation is repumping. In those locations where waste treatment processes have been installed but outgrown, the water recovery process is an ideal method.

Also, as mentioned above, the regenerants

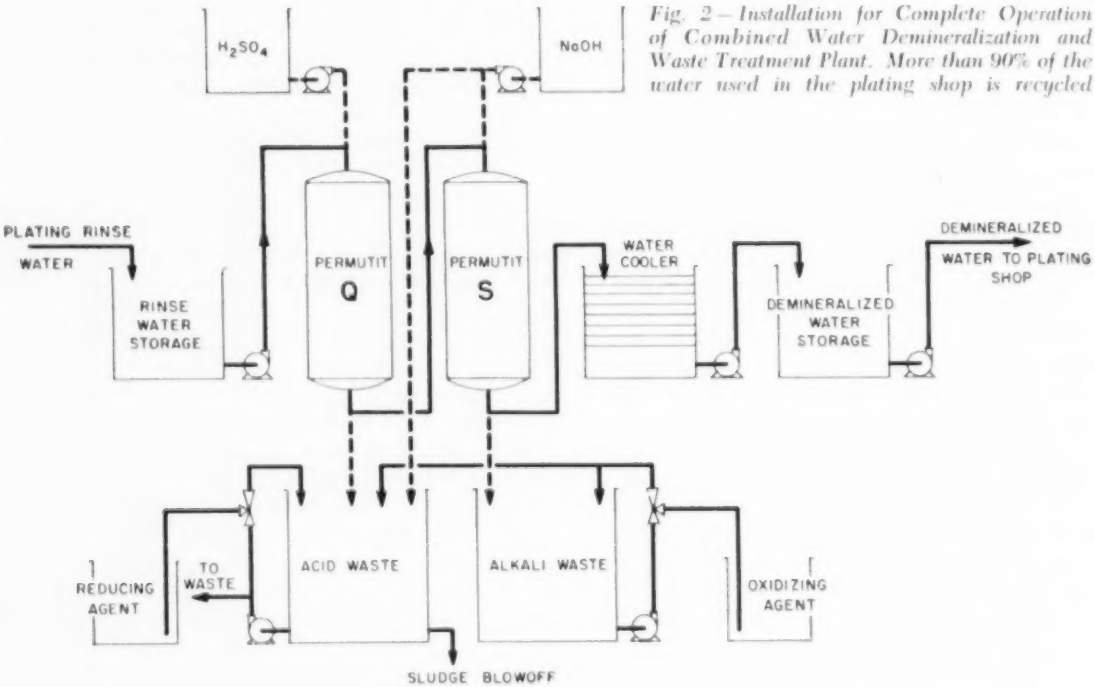


Fig. 2 — Installation for Complete Operation of Combined Water Demineralization and Waste Treatment Plant. More than 90% of the water used in the plating shop is recycled

produce ideal conditions in the waste solutions for oxidation of cyanides and reduction of chromate. The acid and alkali for the waste treatment steps also produce the demineralization of the water. The quantity of reducing and oxidizing agents is also reduced somewhat. In the case of the oxidizing agent, if chlorine is used, for instance, it is necessary to produce the same chlorine residual in a smaller volume of water and hence less chlorine is used. Also, since the actual waste treatment steps are batch operations, there is little likelihood of overfeeding the oxidizing agent, which in turn would require a greater quantity of the reducing agent, or of overfeeding the reducing agent itself.

This water recovery process has advantages of both batch and continuous waste treatment. The water treatment is continuous and the waste treatment is batch. As with continuous treatment processes, the equipment required is relatively small and consequently the requirements for space are small. As with batch operation, there is little likelihood or danger of automatic control equipment becoming inoperative and producing an overtreated or undertreated waste. Also, constant attention is unnecessary, and the tanks for acid and alkali waste treatment are ready for use in treating dumped plating bath if necessary.

To illustrate to some degree the economics of treatment, we have chosen to compare it with the treatment that was described at the 7th Waste Conference by I. D. Cox of the Ford Motor Co., Monroe, Mich. The results of this comparison are shown in the accompanying tabulation. Space requirements and the operating cost are reduced and the quality of the water actually used for rinsing is greatly improved. In addition, the amount of sludge to be wasted is reduced.

In many locations it will be found that a combination of this over-all treatment with ion exchange recovery from some of the main baths will be attractive. For instance, it would be desirable to incorporate, in any system such as the one described in the tabulation, recovery units from the main tanks. This is of course particularly true where a large tank containing considerable chromic acid must be dumped at intervals. A cation exchange unit would overcome this problem.

Comparison of Costs for Water and Waste Treatment

Factor	Separate			Combined	
Flow	550 gal. per min.* CrO_3 wastes (22 ppm.†) 450 gal. per min. CN wastes (43 ppm.)			1000 gal. per min. total (100 ppm.)	
Contamination	144 lb. CrO_3 234 lb. CN			144 lb. CrO_3 234 lb. CN 400 lb. miscellaneous electrolytes	
Operating cost	Water (8.5¢ per 1000 gal.)		$122.00	Water	$ 12.00
	Waste: Chlorine		143.00	Chlorine	143.00
	Sulphur dioxide		26.80	Sulphur dioxide	26.80
	Lime		1.73	Lime	1.73
	Caustic soda		57.80	Caustic soda	72.00
			$351.33	Sulphuric acid	24.00
					$279.53
Equipment cost (does not include control building, lagoon or installation)	Water: 2 sludge blanket units (500 gpm.)		$24,000	Demineralizer	$90,000
	4 water filters		20,000	2 storage tanks	25,000
	Piping, pumps, etc.		10,000	2 treatment tanks	16,000
	Total for water	$54,000		Pumps, piping, chemical feeders, etc.	50,000
	Waste: 4 chromate holding tanks		$72,000	Total	$181,000
	3 cyanide holding tanks with mixers		16,000		
	2 sludge blanket units (400 gpm.)		22,000		
	Pumps, feeders, piping, etc.		50,000		
	Total for waste	$160,000			
	Grand total	$214,000			
Space required	Water 2,100 sq.ft. Waste 9,800 sq.ft. 11,900 sq.ft.			Total, 2400 sq.ft.	

*Otherwise noted as gpm. †Parts per million.

Properties and Structure of Titanium After 30-Min. Heating at 1200 to 2000°F.

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AVAILABLE LITERATURE on titanium gives no data on room-temperature properties after heating in air above 1000° F. Therefore, an investigation was made to determine the changes which occur in the mechanical properties and microstructure of annealed titanium after a short time at 1200 to 2000° F.

A single sheet of annealed, commercially pure titanium (Rem-Cru RC-70), 0.040 in. thick, was used for this investigation. This metal normally contains, as impurities, traces or iron, oxygen, nitrogen (0.001 to 0.10%), and carbon (0.05 to 0.20%). Tension coupons machined from it were placed in an electric muffle furnace and heated in air at 1200 to 2000° F. for ½ hr. These samples were air cooled and tested at room temperature to determine their ultimate tensile strength and elongation. Results are summarized in Table I.

These data indicate that the room-temperature tensile strength of the titanium sheet increases to a slight maximum after heating to 1500° F., and rapidly decreases after heating above 1700° F. The very low tensile strengths obtained after heating above 1700° F. do not represent the actual strength of the material, since the values were computed on the original thickness of the sheet, and at 2000° F. (for example) the surface scale amounted to 70% of the original thickness. Elongation remains high after heating at 1500° F., drops abruptly at 1600° F., and becomes zero above 1700° F. This embrittlement of titanium is generally ascribed to the absorption of alloying gases from the air, principally oxygen and nitrogen.

Metallographic specimens taken from the coupons were prepared by sanding on successively finer papers through No. 4/0 grit, and polishing with Linde A-512 abrasive compound on a silk cloth and finally on an AB Microcloth-covered lap. Specimens were etched 1 to 3 sec. in solution No. 1 (composition tabulated below) to remove the disturbed surface metal, repolished quickly on the final lap, and re-etched in solution No. 2 until the desired contrast was obtained.

Table I — Effect of Heating Titanium in Air for ½ Hr.

TEMPERATURE	ULTIMATE TENSILE STRENGTH	ELONGATION IN 2 IN.	AVERAGE GRAIN DIAMETER
As received	82,500 psi.	41.5%	0.015 mm.
1200° F.	86,800	37.5	0.015
1300	89,100	37.0	0.015
1400	92,300	38.2	0.015
1500	93,300	32.7	0.015
1600	93,000	12.3	0.030
1650	—	—	0.045
1675	—	—	0.060
1700	93,300	0	0.150
1800	56,200	0	0.175
1900	39,500	0	0.200
2000	300	0	0.175

COMPOSITION	No. 1	No. 2
Nitric acid (conc.)	20 cc.	5 cc.
Hydrofluoric (48%)	10	2
Water	70	93

Microscopic examination indicates that an equiaxed, fine-grained alpha structure exists after heating to 1400° F. At 1500° F. the alpha-beta transformation begins to take place at the grain boundaries. The transformation is approximately 50% complete at 1600° F., 80% complete at 1675° F., and essentially 100%

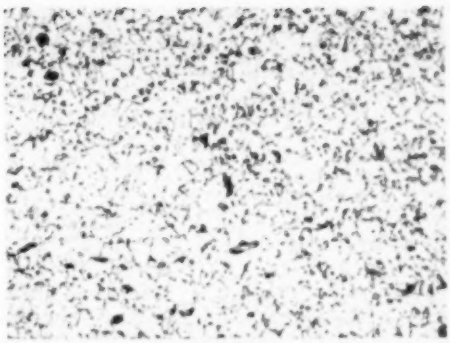
complete at 1700° F. Various stages in the alpha-beta transformation are illustrated in the assemblage of micros at the right.

Actually, in chemically pure titanium the beta phase is stable only at elevated temperatures (above 1615° F.), and on cooling forms the acicular alpha structure appearing in the photomicrographs. Grain growth is quite pronounced above 1700° F., as is also shown in the micros; actual grain sizes are listed in Table I.

Titanium is very reactive with air at elevated temperatures, and above 1500° F. an appreciable alloy layer was formed on the surface of our coupons. This layer appears to be an alloy of titanium rich in oxygen and nitrogen. After heating at 1600° F. for 30 min., this zone was 0.0007 in. thick and it increased to 0.0047 in. as the result of heating at 2000° F. for 30 min.

Above 1800° F., this alloy tends to deteriorate; voids are formed within the metal and the surface rapidly oxidizes to a thick, loosely adherent scale. At 2000° F. this scale was 0.014 in. thick on each side of the sample – equivalent to 70% of the original thickness of the material. The visual appearance of the surface of the coupons and the approximate thickness of the alloy layer and scale are summarized in Table II.

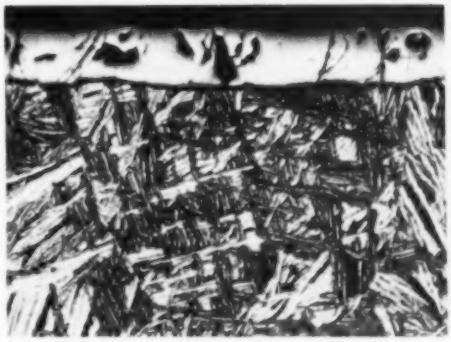
This investigation indicates that annealed titanium may be used for applications involving very short exposure (30 min. max.) at temperatures up to 1500° F. in air. Above this temperature the material becomes excessively brittle as the result of its reaction with gases in the air. Prolonged exposure of the metal to temperatures above 1000° F. produces similar embrittlement.



1400° F.



1600° F.



1800° F.



2000° F.

Commercial Titanium Sheet After Heating 30 Min. in Air. 150 ×. Equi-axed alpha up to 1400°; beta transformation well under way at 1600°, complete at 1800°. Surface layer (light-colored), high in nitrogen and oxygen, thickens rapidly above 1600° F.; at 2000° this alloy layer (central strip) is 0.005 in. thick, and much of the metal has been converted to a loosely adherent brown scale (top third of the micro)

Table II – Thickness and Appearance of Scale

Temperature	Visual Appearance of Surface	Approximate Thickness	
		Alloy Layer	Scale
1300° F.	Light gray	—	—
1400	Light yellow	—	—
1500	White yellow	—	—
1600	Yellow-orange; loose scale	0.0007 in.	0.00006 in.
1700	Yellow-brown; loose scale	0.0007	0.0015
1800	Yellow-brown; loose scale	0.0018	0.002
1900	Yellow-brown; loose scale	0.0032	0.004
2000	Yellow-brown; loose scale	0.0047	0.014

• An Eminent Living Metallurgist •



Augustus Braun Kinzel

President • Union Carbide & Carbon Research Laboratories

A RARE ABILITY to beneficiate the thinking of his associates, plus a brilliant knack for channeling theoretical physics into industrial practice, has placed Augustus Braun Kinzel among this generation's prime metallurgists. He is a scientist-executive whom his professional colleagues continue to honor. He is president of Union Carbide & Carbon Research Laboratories and vice-president of Electro Metallurgical Co., a division of Union Carbide & Carbon Corp., the billion-dollar industrial group whose products become the raw materials for almost every processing industry of the U. S. and Canada.

Gus Kinzel was born in one of New York's last farm mansions on July 26, 1900. The home stood on the Manhattan bank of the East River until John D. Rockefeller bought the area for the Rockefeller Institute for Medical Research. The elder Kinzels continued to live in that stimulating neighborhood; he was a concert pianist, she a college teacher of mathematics. They had three lively, sociable sons. One is now an esteemed corporation lawyer, another a president of a steamship line.

Gus, the eldest, was notably persistent in asking "why", and notably able to understand the answers. He demonstrated a powerful visual imagination that enabled him to reassemble machines during boyhood, and in young manhood to appreciate many concepts of physics. On the run, as it were, he learned the piano, German and French, history, literature. When he was 18 he graduated from Columbia University, A.B., cum laude in mathematics.

This was 1918 and World War I. Forward-looking concerns, even as today, were combing the universities for proto-engineers and proto-researchers. But Gus Kinzel insisted on enlisting. Came the Armistice and unusually quick demobilization. Then General Electric hired this apt young man for the Pittsfield laboratories but released him to attend M.I.T. In a year he had a B.S. in Engineering. The French University of Nancy had an American-endowed fellowship open. Gus Kinzel won it, and in another year had Nancy's D. Met. Ing. *au titre étrangère*, to be followed a few years later by its Sc.D. for a dissertation on welding. He returned to G.E., but soon joined Henry Disston's steel plant near Philadelphia where he stayed two years. While there he also taught advanced metallurgy in extension courses at Temple University.

Now the U. S. economy was in the postwar boom of the 1920's. Young Dr. Kinzel, wise and alert, applied the saw that he always urges others to use in shaping their careers, to wit: "Join a growing concern and give all of yourself to its affairs."

His choice was Union Carbide and Carbon Corp. Aggregated only since 1917, its mutually supporting parts all depended upon astute applications of pure research. One of the notable scientist-technologists on the staff was George Oliver Curme, Jr., pioneering aliphatic chemist, now head of all Carbide's research. Another was the late (1875-1942) Frederick Mark Becket, pioneer of heat and scale resisting alloys. Carbide hired provident Dr. Kinzel as research metallurgist in 1926. After that it was up and up for him — group leader, chief metallurgist, vice-president of Union Carbide and Carbon Research Laboratories, Inc., and since 1948 president of that company. Since 1944 he has also been Electro Met's vice-president for research.

One of the very first things he did for "Carbide" was to demonstrate by mathematics the value of elliptical heads for pressure vessels. His two broad fields became welding and alloy steels. He has designed a portable testing machine, explored the nondestructive testing of welds by sonic and X-ray methods, planned what is labeled the "Kinzel bend test". His studies of deoxidizing and alloy elements solved difficulties of steel welding. He also worked out methods of powder cutting and scarfing of stainless steel. He has some 40 patents in his name. His latest achievements have been incorporated in his firm's new alloy plant at Marietta, Ohio. Here, after a decade of laboratory research and pilot-plant operation under his general direction, a new variety of low-carbon ferrochromium for expediting manufacture of the stainless steels is being produced and new electrolytic plants for tonnage production of chromium metal and manganese metal are being built.

He co-authored the Engineering Foundation's "Low-Chromium Alloys" (1937) and "High-Chromium Alloys" (1940). His reports on impact properties, inclusions, and deoxidation practices continue authoritative. He created "Cromansil", considered the first widely used "low-alloy, high-strength steel". This he subsequently modified with zirconium for another popular group of strong steels. His vanadium refining methods made this metal

industrially available; its future importance is bound to grow, since it is associated with the uranium ores of the Colorado plateau. At present, he and his group are preparing a series of master alloys designed to improve the properties of titanium.

In the metallurgy relating to nuclear fission and fusion, this scholar's personal knowledge has been called on from the very start – at Los Alamos, Argonne, Oak Ridge (U.C.C. operated), Knolls (G.E. operated), Brookhaven. He helped draft the Manhattan District Report for world control of atomic energy that was the basis for the Lillienthal and Baruch plans. He did other specialized work for the Government during World War II that was important enough to give him the simulated rank of brigadier general.

He lectures before learned societies, congresses and institutions, and has received their honors. These epitomize his achievements – 1944 A.W.S. Adams Lecture ("Solid Phase Welding"); 1947 ASM Campbell Lecture ("Ductility of Steels for Welding"); 1947 A.W.S. Miller Medal; 1948 ASM Distinguished Service Award (for constructional alloy steels); 1952 A.I.M.E. Howe Lecture ("Chromium Carbide in Stainless Steels"). He is also an expert on metallography, as witness his Sauveur Lecture before the Philadelphia Chapter ASM, published in *Metal Progress* for January 1953.

He has guest-lectured in London and Rome on welding, and at the instance of the U. S. Government in Moscow on structural steels. (He reads Russian and Spanish – with dictionaries.) He has talked in German at Düsseldorf, Munich and Zurich; in French at Brussels, Paris, Nancy. In Stockholm recently his audience was perturbed by U.S.S.R. intimidations. He oriented them to the wisdom of N.A.T.O. more wittily and effectively than a professional diplomat might, by means of a united-we-stand, divided-we-fall illustration using a boxful of Swedish matches.

Among his professional societies he has held elected posts with the Engineering Foundation, A.I.M.E., Welding Research Council, A.W.S., and International Institute of Welding; and appointed posts with A.I.M.E., A.S.T.M., A.S.M.E., A.S.M. He is an honorary member of the British Acetylene Association. He is also a member of the visiting committee to M.I.T.'s department of metallurgy, and last spring became chairman of the advisory committee of New York University's Institute of Mathematical Sciences, and chairman of the Naval Research Advisory Committee.

The education of researchers and engineers should include the humanities, Dr. Kinzel urges. M.I.T.'s new optional system of three years in a liberal arts college and two years in a technical school is ideal, in his opinion. Only last March U. C. & C. started to approach such a goal with $500,000 a year to educate 400 men and women annually for executive and administrative careers in business and industry. This complements A.S.M.'s own educational program.

This dynamic executive's office in mid-Manhattan is ornamented with symbols of his interests – a musically thematic etching, a modernistic "sculpture" in shining metal tubing, a cuneiform extract from the 4100-year-old Code of Hammurabi ("If a builder built a house that collapsed, he shall rebuild the house at his own expense").

A half-mile saunter from his office is his Park Avenue apartment. Mrs. Kinzel has painted the walls with scenes from the family's history. One mural shows his birthstead on the Manhattan shore. There are framed portraits of and by the girls, a chess game in suspended progress, a grand piano and – set in a wall – a television screen, a white-glazed bust of Shakespeare above his books and tobacco pipes, and in an unanticipated nook a compact carpentry shop. Handy Gus Kinzel builds utilitarian modern furniture, some shaped according to algebraic equations, if you can imagine it. His engineered two-piece dining table has the curves of a boomerang.

The family is a joyous swarm. He has a summer place for them at Lake Queechy, in the Berkshires, which he keeps stocked with five sailboats. Last summer he chartered the *Amberjack*, once F. D. Roosevelt's favorite, to give his growing son Fritz both a taste of salt water and a touch with history. For summer music the family goes to the famed school at nearby Tanglewood, Mass.

The Kinzels married in 1945, a second marriage for both of them. Each had two daughters of the same ages. The girls had an unattached schoolmate. With no stint of love the Kinzels absorbed her into the family as their sixth child. One of the girls married in 1949, the others in tumultuous succession during 1951. There are already five Kinzel grandchildren. During this brief period young brother Fritz grew 15 in. and now, at 16, stands 6 ft. 2 in. Mrs. Kinzel, who likes "to think of myself primarily as my husband's wife", is currently writing a detective novel. The solver-of-the-problem is – you guessed it – a pipe-smoking metallurgist! MYRON WEISS

Light Metallurgy

Lab Boys

THESE REFLECTIONS on that shy but ubiquitous creature, the Lab Boy, are prompted by many years of observation of the European sub-species. The subject is one which has received little attention of recent years in technical literature, and it would be well (as always) to lay down a clear definition at the outset. The term "Lab Boy", as used in this treatise, signifies an unqualified junior laboratory assistant, but one who is in the process of acquiring scientific qualifications by some mysterious method of his own, whose precise nature need not be specified. His scientific studies may be part-time and slow, or spare-time and slower; but one day he will be able to put some letters or other after his name, and on that same day he will either expect a considerable increase in salary or obtain employment elsewhere.

The intelligent Lab Boy is the indispensable adjunct of metallurgical science, as the top sergeant is the backbone of armies. His natural pursuits cover a wide range. He may be found holding things, soldering things, screwing things into walls, sawing, filing or polishing specimens, assembling or dismantling apparatus – in fact, performing any of a wide range of functions which the scientist is unwilling or unable to perform for himself.

The basic laws governing the activities and growth of the Lab Boy were discovered and enunciated by the infallible Prof.-Ing. Glumpf in a brilliant paper (*Z. Phys. Welt*, 1882, Vol. 183) which has never received the attention it deserves, perhaps because of the incomparable turgidity of the language which the famous old professor used. Glumpf formulated three fundamental principles to which he gave the name *Wissenschaftlichelaboratoriumsknabengesetzungen;* but they are more usually referred to among the English-speaking peoples as the Laws of Practical Thermodynamics. The First Law runs, in all its majestic simplicity, thus:

"The capable Lab Boy is a *sine qua non.*"

The young scientist usually becomes painfully aware of the truth of this First Law at an early stage in his career. Laboring, shall we say, to determine the lattice constants and transformation characteristics of the sigma phase, he finds himself thwarted at every turn by the startling intractability of the material world. The academic aspects of the problem are clear to him; it is the need to translate temperature determinations into terms of non-



breaking thermocouples, and vacuums into effectual pumps, that causes him to stumble into unforeseen impasses. From these the indefatigable Lab Boy delivers him, if he has been so fortunate as to find one in a suitable stage of experience and development. If not, the lattice constants of the sigma phase commonly remain undetermined.

On first learning this, the young scientist begins to wonder – in that mood of despair that overtakes us all at such formative times – whether he is really necessary at all, and whether the Lab Boy could not quite well be left to do it all without him. It is then that the young scientist's superior, if he is wise and percipient as he should be, will remind him of the Second Law of Practical Thermodynamics, which the young scientist has probably learned at some stage of his academic training but since forgotten, along with a lot of other things. The Second Law runs, as he should know, as follows:

"No Lab Boy, however capable, if left to himself, will determine the lattice constants of

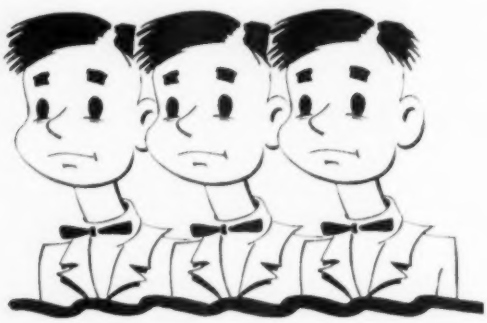
the sigma phase, or any other phase."

The reason for this strange phenomenon lies concealed somewhere in the booming depths of the human psyche. Glumpf never explored it fully, being unarmed with our later knowledge of the mysterious workings of the mind.

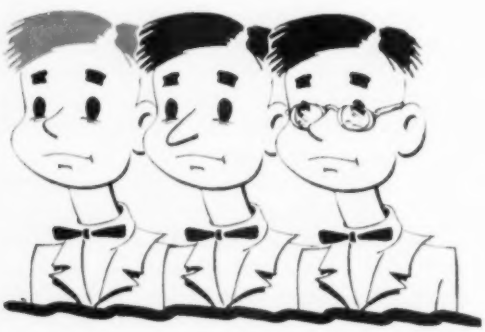
The Third Law is, like so many other Third Laws, divided into two parts:

"1. Each Lab Boy is a separate entity, whose differentiation, negligible on commencing employment, increases at a rate proportional to the square root of the time of employment.

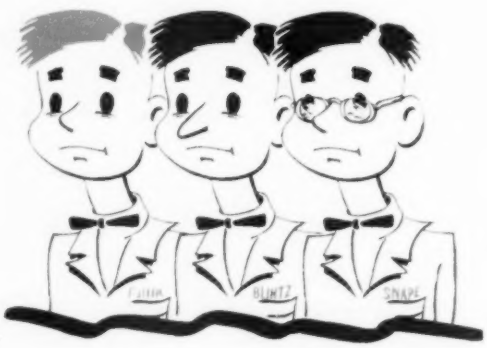
"2. All Lab Boys tend in time to become young scientists."



The daring concept of the Differentiation of Lab Boys, referred to in the First Part of the Third Law, is a complex matter requiring further elucidation. Briefly stated, it means that at first sight any Lab Boy looks like any other Lab Boy. It is only after a few days' cautious



experimentation that the new Lab Boy begins to be clearly recognizable as, say, the One with the Rusty Hair, to distinguish him from the One with the Beak, and the One with Steel-Rimmed Glasses. A week or two later a sudden transformation takes place. The new Lab Boy is found to have become Blintz or Snape, yet it is usually impossible to say at what precise moment this transition takes place. From this moment Blintz (or Snape) begins to take on, with some rapidity, a whole miscellany of known attributes, such as a sick aunt in Florida, a genius for blowing curly bubbles from glass tubing, an enthusiasm for ice-hockey or regrettably careless habits with reagent bottles full of sulphuric acid.



At this stage of his development the Lab Boy begins to fall into one of two great subdivisions, carelessly but aptly referred to as the Useful and the Useless. There are innumerable sub-subdivisions, but the basic classification is usually quite clear. Differentiation increases in both categories, but once in his category the Lab Boy almost universally stays in it.

The Lab Boy of the first, or Useful, category, when fully differentiated and at the height of his powers, is a noble and many-sided creature. He smoothes away the cares that beset the research scientist, as the mother smoothes the brow of her fretful infant. The scientist has only to walk distractedly through some derelict room, the Fully-Differentiated Lab Boy at his elbow, and mutter something about the sigma phase. The next time he passes that way he finds the room swept, furnaces plugged in and panting for work, vacuum pumps clicking away with domestic zest, and charts calibrating everything with everything else covering every available inch of wall space.

At the final stage of the Lab Boy's development he is *almost* capable of operating in complete independence. He still has to be given his initial push in the direction of the sigma phase, for the Second Law is inexorable; then he not only does all the subsequent work, but can be blamed for everything that goes wrong. For instance, the scientist may have failed to observe that his apparatus, as originally planned by him, permits quantities of nitrogen to creep unseen into his melt, rendering his phase less sigma than it might be. He fully expects the

Lab Boy to preserve him from such misfortunes by reconstructing, if needs must, the entire apparatus and radically modifying the experimental procedure.

Sometimes he may even do the Lab Boy the honor of conjoining his name to his own in his paper on the phase, which finally appears under the authorship of Jimson, Tomkin, FitzEustace and Snape. Jimson is the Head of the Laboratory, and has discussed the experiments briefly with the scientist for half an hour before lunch. Tomkin is the Deputy Head, and has delayed the publication of the paper for several months by insisting that FitzEustace should spend three-quarters of his time doing Tomkin's own development work on galvanized buckets. FitzEustace, the Scientist, reads up all the previous papers on the subject, plans the experimental work initially, and writes the paper; and Snape is the one who does all the actual work and takes the blame for the nitrogen. The Scientist can then spend all his day, when he is not working on Tomkin's buckets, in the library, planning his next work on Tesselated Stresses in Titanium, and waiting for the Lab Boy's figures to come rolling in.

Such a state of affairs is too idyllic to last. The day comes when the Fully-Differentiated Lab Boy no longer manifests himself at the elbow in times of need. Inexorable fate has swept him away. Snape is gone, and in his place is the New One with the Bony Hands, who has to be painfully instructed in every trifling matter. The march of Science lags.

What has happened is that the Second Part of the Third Law has operated. As the larva becomes a chrysalis and finally a butterfly, losing one set of attributes and gaining another, so has the Lab Boy emerged as a Scientist, a thing of great beauty able to fly through the air but no longer capable of boring through wood.

One day, visiting some other learned establishment, the bereaved scientist observes a dis-



mal sight. It is a Young Scientist. He is wound about with wire, there is asbestos wool in his hair; his left thumb is bandaged where he has struck it with a blunt instrument. He is struggling in vain to construct some apparatus; there is a crash of porcelain. The sympathetic observer approaches nearer, and perceives that the Young Scientist is none other than good old Snape. The metamorphosis has occurred!

R. P. Lister

Book Review

Practical Physical Metallurgy

Nonferrous Physical Metallurgy, by Robert J. Raudebaugh. 350 p., 130 illustrations. Pitman Metallurgical Series. Pitman Publishing Corp., New York City.

The Editor – I see on your table here the book you promised to review for *Metal Progress* – or did you promise?

A. N. Alchemist* – I did not. It is obviously a well-printed and carefully organized book which gathers together a great number of facts, but I was frightened off by the stipulations you set for a book review. I am sure I haven't the ability to write such an essay.

Editor – It's too bad it sounded so formidable. I sent along a copy of *The Saturday Review* (of Literature) to illustrate what I meant when I wrote that a book review department in *Metal Progress* should aim at the high

*A. N. Alchemist is by no means an imaginary being. He would rather withhold his name, although if it were given, many readers would recognize it as one of our most competent consultants in metallurgy.

Book "Intereview"

quality of that magazine rather than take the easy way out and merely print an expanded version of a book's table of contents and call that a review.

ALCHEMIST – A fine ambition, but I doubt whether one can reach it. It would be easy to say that this book is a systematic summary, with chapters devoted to aluminum, magnesium, copper, nickel, white metals, rarer metals, and powder metallurgy. Each chapter follows a general pattern, describing the commercial alloys, metallography, casting practice, hot and cold work and other fabricating processes, and uses. Bibliographies are restricted almost entirely to the literature since 1940. But that kind of factual information is hardly the kind of thing you are likely to find in *The Saturday Review*.

As a matter of fact, one of the reviews in that magazine intrigued me. The critic disagreed with the book's author about the political consequences of Napoleon's divorce from Josephine, so the review was really an essay on a certain incident in the dictator's reign – made me quite sympathetic with the empress, in fact. But how can something of that sort be done with Prof. Raudebaugh's book?

EDITOR – Find some place important where you disagree with him, and argue the point!

ALCHEMIST – It would take too much time to find an *important* error, as you put it. In fact, it is easily possible that there is none. The author has summarized a great mass of recent literature with skill. I have examined the few pages which refer to my own specialty and I would criticize one statement as being too broad – that is to say, what he says is true in certain important instances, but in other important circumstances it is not true. However, such lack of precision is bound to occur in any account which is as brief as this book. He attempts to cover all the industrial metals in a space that would be crowded with a comprehensive discussion of only one metal – nickel, for example.

EDITOR – Well, then, why don't you write an essay about the danger of being so brief as to be misleading versus the danger of being so encyclopaedic as to be boring?

ALCHEMIST – You yourself should write such an article. This concerns literary techniques rather than metallurgical. Even so, I would not want to criticize Prof. Raudebaugh's treatment unless I knew something about his reasons for compiling the book, and his preface gives me no clue. There may be a considerable demand for such a book as his – which I would think is pitched at the college student or as a general review for the more mature. Personally I prefer books like the fourth one in this Pitman Metallurgy Series where Comstock, Urban and Cohen discuss "Titanium in Steel", exhaustively, authoritatively, in the light of many years of specialization in just that one corner of practical metallurgy.

And now that I think of it, those words "practical metallurgy" remind me of another thing which bothered me, and that is the title of the book. Why is it "Physical Metallurgy"? I think that Raudebaugh is all mixed up with Sachs and Van Horn. Sachs and Van Horn's old book is called "Practical Metallurgy", yet I think it is more physical metallurgy than Raudebaugh's new book called "Nonferrous Physical Metallurgy" – which to me refers to practical metallurgy. At least, in his preface Raudebaugh says that extraction of metals from ores is production metallurgy and "subsequent adaptation of the refined products to the use of man" is physical metallurgy. Am I right in thinking that as it is used today the term physical metallurgy has to do more with the physics of metals? Physical metallurgy – again, as I understand the term – has little directly to do with shop operations such as extrusion or machining, or practical uses of the metals and alloys and such things which occupy a considerable portion of this new book. Why can't you writing and teaching metallurgists agree on your terms?

EDITOR – Editors and authors don't make usage! They follow it. Years ago Walter Renton Ingalls, the influential editor of *Engineering and Mining Journal*, decided that a plant where "production metallurgy" was practiced should be called a "smeltery". It was a smelter; it still is a smelter. So I, for one, would grant Prof. Raudebaugh the privilege of calling his book "Nonferrous Physical Metallurgy" if he wants to, even if his mental picture of "physical metallurgy" is different from mine. His may be the true one.

ALCHEMIST – On the other hand, he may be misleading potential purchasers of his book. It is really an up-to-date summary of the important information on all the commercial metals except those alloys based on iron. Its faults are those inseparable to such a brief consideration of such an enormous field of engineering technology. Its excellences – precision, brevity, timeliness, inclusiveness – may easily outweigh the faults in the eyes of many users.



(A) Sprockets of Ductile Iron on the Trench Hog demonstrate their abrasion-resistance . . . operating in a bath of dirt, sand, gravel, stones, etc., much as gears might run in a bath of lubricating oil.

(B) Cutter Brackets show the impact strength of Ductile Iron. These hold disc type cutters to the main digger chain when operating in extremely stony (or frozen) soil calling for disc-type cutters.

(C) Replacement Bearing Sleeve made from wear-resisting Ductile Iron permits minimum wall section because its strength is much higher than that of gray iron, although it has the same machinability rating.

(D) Cleaner Blades of Ductile Iron mounted at regular intervals on the digger chain withstand battering and abrasion by stones and soil. These parts also prove the impact resistance of Ductile Iron.

(E) Counter-drive Support Brackets are subject to twisting action. Ductile Iron makes possible smaller, lighter brackets . . . with a higher safety factor against breakage.

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- **Resistance to Wear**
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- **High Strength**
- **Superior Machinability**

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Wrought Aluminum Alloys

Compositions, Properties, and Designations of American Commercial Alloys

Compiled by H. S. Jerabek, University of Minnesota, June 1953, from handbooks and specifications of the principal manufacturers, the American Society for Testing Materials, and the Society of Automotive Engineers.

	Designations				Nominal Composition Aluminum = Balance						Form Tested	Tensile Strength (c)		Yield Strength (c)		Elongation % in 2 In.		Brinell Hardness	Shear Strength	Endurance Limit (d)	Cold (e) Bending	Corrosion Resistance (f)	Characteristics and Uses
	ASTM	SAE	AMS (b)	ALCOA (a)	Cu	Si	Mn	Mg	Cr	Zn		Ave	Min	Ave	Min	Ave	Min						
Alloys Not Heat-treatable (g)	990A	25	4001B	2S-O	(99.0 Al Min.)						1/16" Sheet	13	(5.5 Max)	5		35	30	23	9.5	5	A	A	Commercial Al, good forming properties
			4003B	2S-H14							" "	17	16	14		9	5	32	11	7	B	A	Good corrosive resistance; low yield strength;
				2S-H18							" "	24	22	21	19	5	4	44	13	8.5	F	A	Cooking utensils; sheet and tubing
	M1A	29	4006B	3S-O			1.2				" "	16	(19 Max)	6		30	25	28	11	7	A	A	Similar to Alloy 2S
			4008B	3S-H14							" "	21	19.5	19	17	8	5	40	14	9	C	A	Slightly stronger and less ductile
				3S-H18							" "	29	27	26	24	4	4	55	16	10	G	A	Cooking utensils; sheet metal work.
	MG11A			4S-O			1.2	1.0			" "	26	(29 Max)	10		20	18	45	16	14	B	A	Fairly high strength, fair forming properties,
				4S-H38							" "	40	38	34	30	5	4	77	21	16	G	A	Tubing and sheet.
	G1A			50S-O				1.4			" "	21	(24 Max)	8		24	20	36	15		B	A	Moderate strength and forming properties,
				50S-H38							" "	32	29	29	24	6	4	63	20		G	A	Good corrosion resistance.
	GR20A	201	4015C	52S-O				2.5	0.25		" "	27	(35 Max)	12		25	20	45	18	16	B	A	High strength, fair forming properties,
			4017C	52S-H38							" "	41	39	36	31	7	4	85	24	20	G	A	Sheet, plate, wire, rod, bar, pipe and tubing.
	GR40A			A54S-O				3.5	0.25		" "	34		16		27	18			17		A	New highest strength non-heat-treatable alloy
				A54S-H38							" "	48	45	39	34	8	5			21		A	Sheet for welded construction.
			4182	56S-O			0.1	5.2	0.1		Wire	42	(46 Max)	22	10	35		65	26	20		A	Wire, screening and rivets
				56S-H38							"	60	55	50		15		100	32	22		B	High strength and corrosion resistance.
Heat-treatable Alloys (h)	CG42A	24	4035B	24S-O	4.5		0.6	1.5			1/16" Sheet	27	(32 Max)	11	(14 Max)	19	12	47	18	13	B	E	High strength, Dural type Alloy
			4037B	24S-T4							" "	68	62	48	40	20	17	120	41	20	J	D	Available in almost all wrought forms
				24S-T36							" "	72	69	57	52	14	12	130	42	18	K	D	T36 temper strain hardened after Soln. Heat Treatment
	Clad CG42A		4041B	Clad 24S-T4							" "	64	58	42	37	19	11		40		K	A	Clad with coating of 99.3% min. aluminum.
				Clad 24-ST86							" "	70	66	66	62	6	3					A	T86 Soln. H.T., Strain hardened and artificially aged.
	GS11A	281	4025B	61S-O	0.25	0.6		1.0	0.15		" "	18	(22 Max)	8	(16 Max)	22	16	30	25	9	B		Very good forming properties, Fair strength,
			4026A	61S-T4							" "	35	26	21	16	22	16	65	24	13.5	E	B	Intermediate corrosion resistance,
			4027A	61S-T6							" "	45	38	40	35	12	10	95	30	13.5	F	B	All wrought forms except forgings.
	Clad CS41A			Clad 14S-T6	4.4	0.8	0.8	0.4			" "	68	64	60	57	11	8		41		K	B	Clad with 0.7% Si, 1.3% Mg, 0.25% Cr alloy.
	ZG62A		4044	75S-O	1.6			2.5	0.3	5.6	" "	33	(40 Max)	15		17	10	60	22		D	E	Highest strength commercial alloy
			4045	75S-T6							" "	82	77	72	66	11	8	150	49	24	K	D	Forming properties somewhat inferior
	Clad ZG62A		4049	Clad 75S-T6							" "	76	72	67	62	11	8		46	13	J	A	Clad with 1% Zn, bal. Al.
	GS41A	260	4153	14S-T4	4.4	0.8	0.8	0.4			Extrusions 0.5"	70	64	60	58	13	7	135	42	18		D	High strength extrusions with fair ductility.
	CG42A	24	4152D	24S-T4	4.5		0.6	1.5			" "	68	60	48	44	19	12	120	41	20		D	Strong extrusions with good ductility.
	GS11B	282		53S-T6		0.7		1.3	0.25		" "	37	32	32	25	13	10	80	23	13	G	A	Highest strength extrusions, fair ductility.
	ZG62A		4154C	75S-T6	1.6			2.5	0.3	5.6	" "	89	90	79	72	10	7	150	49	24		D	Architectural shapes, fairly good corr. resistance
	GS11A		4150A	61S-T6	0.25	0.6		1.0	0.25		" "	45	42	40	35	17	10	95	30	13.5		B	New alloy similar to 61S
	GS10A		4156	63S-T6		0.4		0.7			" "	35	32	31	25	12	8	73	22	9.5		A	Best workability and corr. resistance in this group.
	CP60A			11S-T3	5.5		(0.5 Pb)		(0.5 Bi)		Rolled Rod	55	45	48	38	15	10	95	32	18		D	Original Duralumin composition now largely replaced.
	CM41A	26		17S-T4	4		0.5	0.5			0.5	62	55	40	32	22	16	105	38	18		D	Free cutting, screw machine products
	CS41A		4135F	14S-T6	4.4	0.8	0.8	0.4			Forgings 0.5		65		55		10	125	42	18		D	High strength forging alloy
	CN42C	270	4140C	18S-T61	4			0.6	(2 Ni)		" "	61	55	46	40	12	10	120	39	17		D	Good strength at elevated temperatures
	CN42D		4142	B18S-T72	4			1.5	(2 Ni)		" "	48		37		11		95	30			D	" " " " " "
	SG12A	290	4145D	32S-T6	0.9	12.2		1.1	(0.9 Ni)		" "	55	52	46	42	9	5	120	38	16		C	Forged aircraft pistons, high temp. strength.
	SG11A	280	4125C	A51S-T6		1.0		0.6	0.25		" "	48	44	43	37	17	12	100	32	11		B	Moderate strength, best forgability.
	ZG62A		4137	76S-T6	0.6		0.5	1.5		7.5	" "		70		60		14	140	39	17		E	

(a) Commercial alloy numbers originated by Aluminum Co. of Am. S = wrought alloy. Temper designations: O = Annealed H18, 28, 38 (formerly H) = hard rolled; H14, 24, 34 (formerly ½H) = half hard; T4 = solution heat treatment; T6 = solution H.T. plus artificial aging; T72 = solution H.T. and stabilized.

(b) AMS: Aeronautical Material Specifications of the Society of Automotive Engineers

(c) In thousands of pounds per square inch. Yield strength taken at 0.2% permanent set.

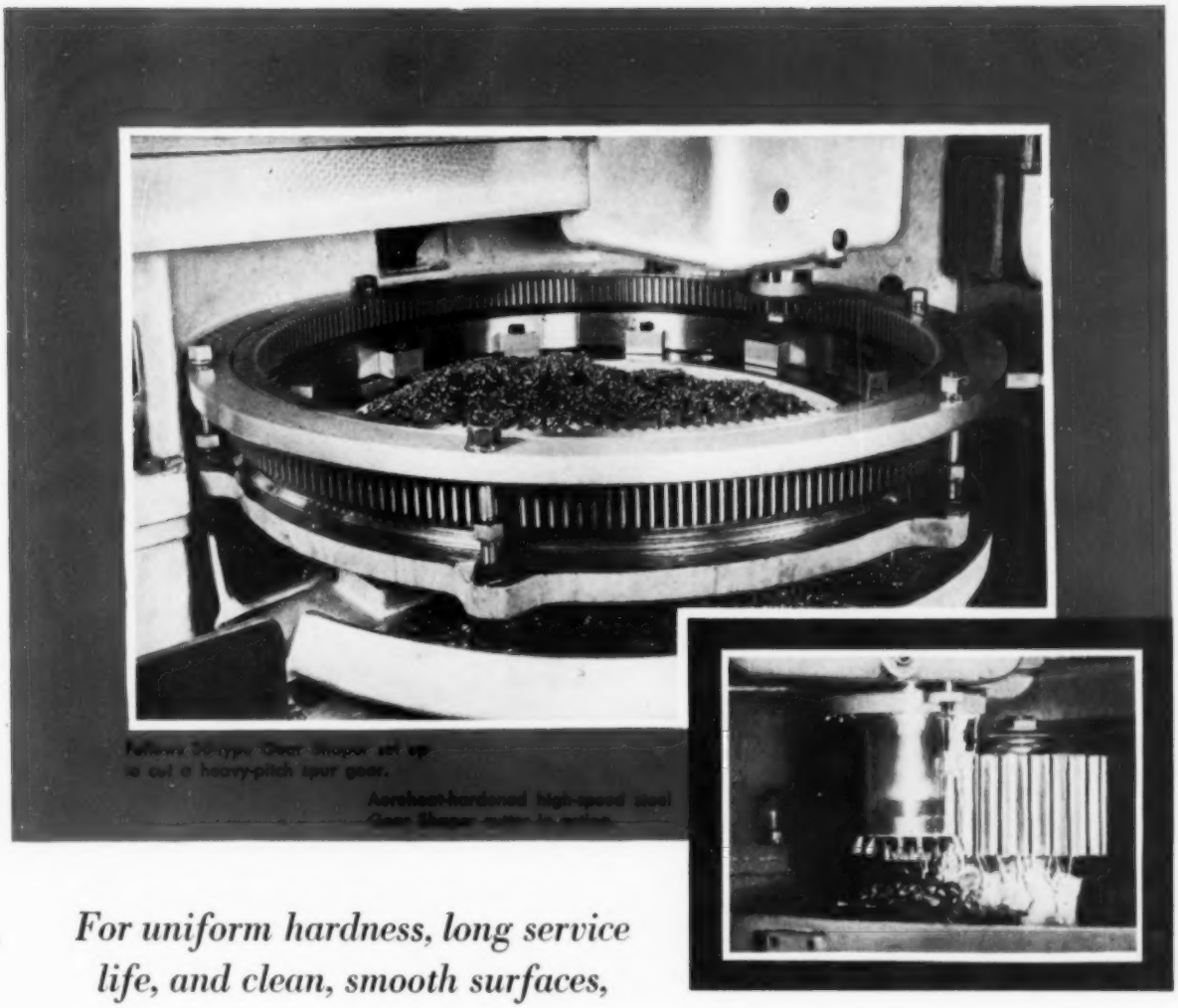
(d) 500 million cycles in reverse bending

(e) Relative forming properties in cold bending. A = best

(f) Relative resistance to corrosion, marine exposure. A = best

(g) Can be hardened by cold work only.

(h) Can be hardened by heat treatment.



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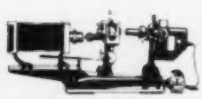
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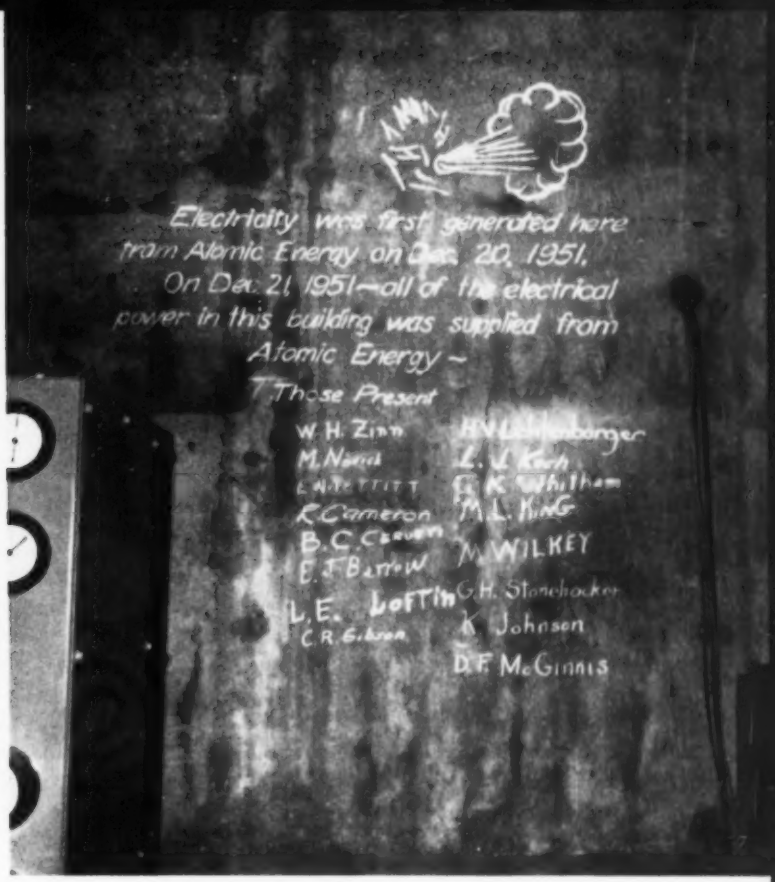
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Digest and Commentary by
The Editor of Metal Progress

100 Engineers Evaluate Atomic Power Plants

IT WAS DISCLOSED officially in the so-called Smyth Report* describing the wartime Manhattan Engineer Project that the incredible amounts of energy in the atomic bomb are released instantly by the same type of chain reaction which operates slowly and under complete control in "thermal" reactors which transmute natural uranium metal (U^{238}) into bomb-stuff, the fissionable metal plutonium. The heat so released at the large plutonium factory at Hanford, Wash., is wasted; purified water from the nearby Columbia River is used to cool the reactors. This carries away quantities of energy of the same order of magnitude as the electricity generated at Grand Coulee and Bonneville dams.

The likelihood that such heat could be converted into electricity has impressed every thoughtful person. From the beginning it seemed to be an excellent peacetime use of atomic energy. However, a safe international agreement could not be reached in the United Nations Organization, and the ensuing cold war caused the American Government to concentrate almost all of its resources on the production of more and better explosives.

Notwithstanding the fact that the U. S. Atomic Energy Commission has a legal monopoly of all fissionable material in this country, C. A. Thomas, vice-president of Monsanto

*"A General Account of the Development of Methods of Using Atomic Energy for Military Purposes Under the Auspices of the United States Government 1940-1945", by H. D. Smyth.

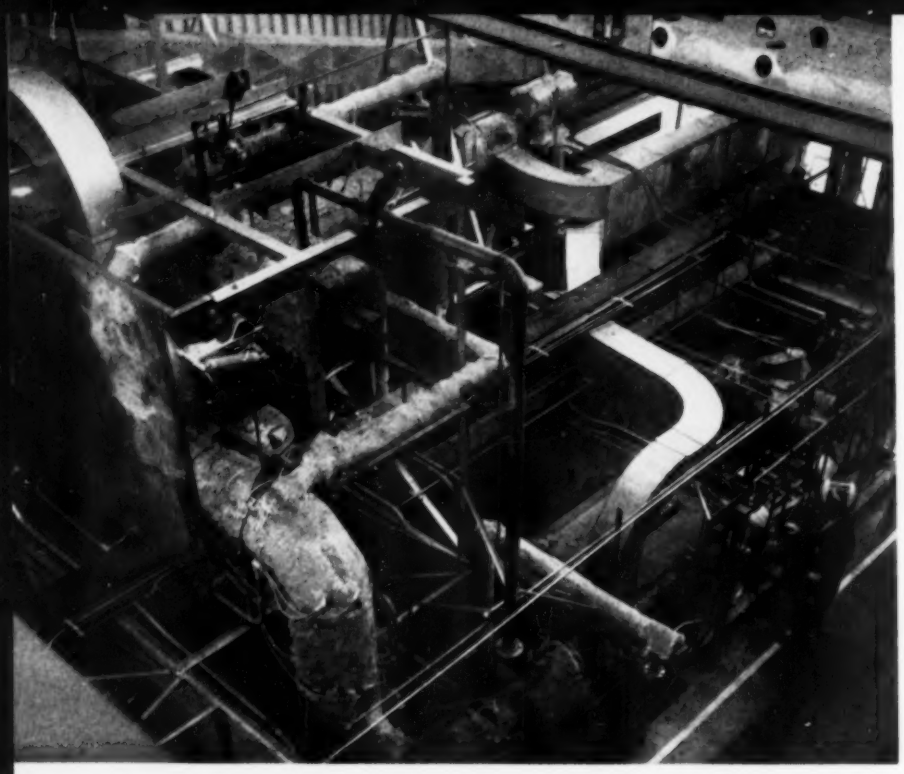


Fig. 1 — Experimental System Handling Liquid Sodium at Knolls Atomic Power Laboratory, Schenectady, N. Y. System is a closed loop, fully instrumented for sodium at any condition up to 1000° F. and 75 psi. Pumps and flow meters operate on magnetic principles, have no moving parts, and are commercially available. (Photo courtesy General Electric Co.)

Chemical Co., proposed to the Atomic Energy Commission that industry might with its own capital design, construct and operate nuclear reactors for production of *both* plutonium and power. Other firms seconded the proposal. Eventually four groups were authorized to make the necessary studies, and more than 100 engineers and scientists of these firms were "cleared" for access to the available data, equipment and personnel. It is estimated that by the time they made their reports, these activities had cost their firms about $1,000,000. These groups were Monsanto Chemical Co. in partnership with Union Electric Co. (designated as Monsanto-Union); Commonwealth Edison Co. and Public Service Co. of Northern Illinois (designated as Commonwealth-Public); Dow Chemical Co. and Detroit Edison Co. (Dow-Detroit); and Pacific Gas & Electric Co. and Bechtel Corp. (Pacific-Bechtel).

The regulations set up by the Atomic Energy Commission provided that the four groups should study existing reactor technology in order to *(a)* determine the engineering feasibility of designing, constructing and operating dual-purpose reactors to produce both fissionable material and power; *(b)* examine the economic and technical aspects of building such reactors in the next few years; *(c)* outline the necessary research and development; and *(d)* recommend industry's role.

In due time these reports were made. The A.E.C.'s Advisory Committee on Industrial Information strongly recommended that pertinent parts of them be published so as to convey as much information as possible to other firms which were not able to make their own studies. Declassifiable condensed versions were prepared by Andrew W. Kramer, editor of *Power Engineering*, and Stanley A. Tucker, manager of publications for the American Society of Mechanical Engineers, and the results have now been published.*

Studies of these teams were limited to a dual-purpose reactor to generate power as well as plutonium for explosives; hence the designs settled on are not necessarily those which would have been selected for power only (with plutonium produced being evaluated as a fuel). Another requirement was for reactors that might be built within the next few years; thus the concepts were usually conservative, the components were of proved design, and the conditions reasonably certain of early fulfillment.†

It appears most significant, therefore, that each group settled on a different reactor type as holding most promise. Again, all four groups agree that dual-purpose reactors are technically feasible, and offer to continue the study of components and of general designs leading to engineering plans.

While the bulk of the reports have to do with considerations and mechanisms of most interest to the power engineer, the following

*"Reports to the U. S. Atomic Energy Commission on Nuclear Power Technology", May 1953, 90 p., U. S. Government Printing Office; price 25¢.

†Those who missed Tom McEnergy's engaging explanation of how reactors work and who need to refresh their acquaintance with some of the terms in this article should turn to p. 92 of the July issue.

Continuous Refining Proposed

outline of the proposals should interest members because in some instances excessive or unusual demands are asked of the metallic materials of construction, and others involve some unique metallurgical concepts. Unfortunately for the present purpose, many details of the specific designs have not been revealed in this public document and therefore will have to be deduced by the attentive reader. Furthermore, in the interest of brevity, only the four preferred reactors will be noted, despite the fact that each team carefully studied more than one type.

Possibly the most intriguing proposal (at least to an engineer with some experience in the smelting and refining of metals) is the one by the Dow-Edison group – the second one described below. All the others contemplate reactors using solid uranium as fuel, and their designs are based on the desirability of cooling this uranium so it is always below the alpha-to-beta transformation (1230° F.). When these fuel slugs are depleted, they will be removed and sent to a distant chemical processing plant for separation of the plutonium and recovery of the uranium. The Dow-Edison conception is that these two operations should be integrated. The enriched uranium should be in a liquid alloy – or at least in a fine dispersion in a molten carrier – and this should be bled continuously into a refining unit right next to the reactor core, where the melt could be purified of plutonium and undesirable fission products by slagging or other pyrometallurgical processes. The report infers that the studies now under way at the A.E.C.'s laboratories are sufficiently advanced to warrant confidence in the success of such a program. One obvious and large problem (although not mentioned specifically) would be the proper materials of construction to hold these hot liquids – "hot" in both the thermal and the radiation sense.

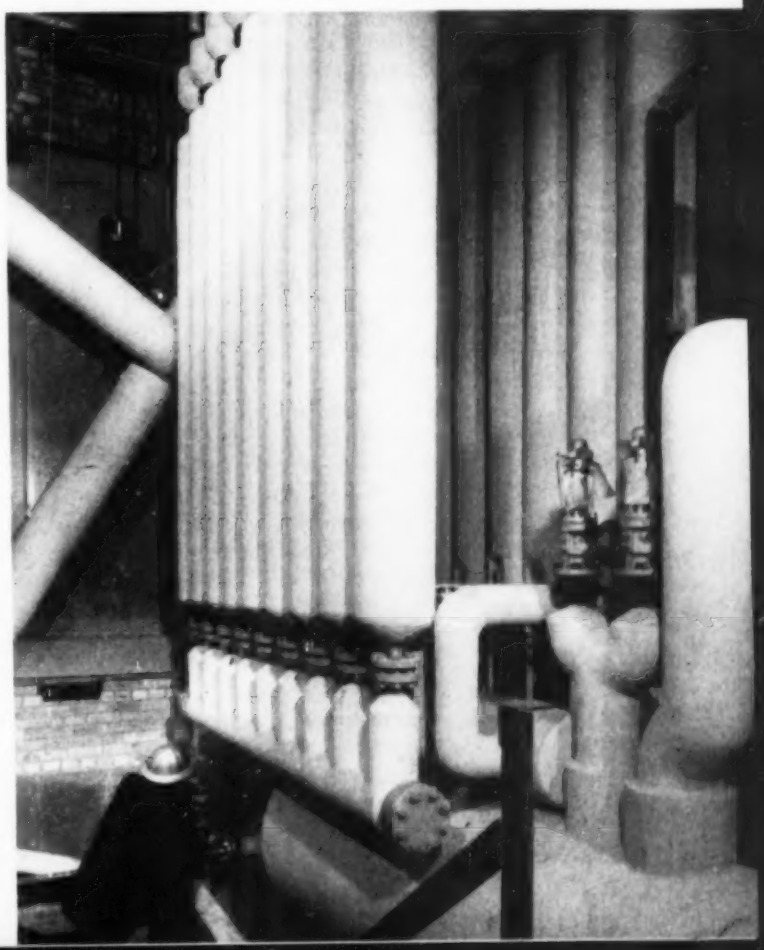
MONSANTO-UNION; CONSERVATIVE

Monsanto-Union selected as first choice a graphite-moderated reactor of Hanford type using slow or thermal neutrons originating in uranium slightly enriched in U^{235} (0.95% instead of the 0.70% in natural metal). Fuel elements will be tubular, cooled both inside and outside. 235 tons of uranium would be needed. Coolant is to be molten sodium which is heated in the reactor to 900° F.; it then generates steam at 500° F. in a heat interchanger and is subsequently cooled (heat being wasted) to 300° F. before its return to the reactor. 554,000 kw. of power would be generated by three low-pressure, low-temperature steam turbines. The thermal efficiency of the entire system is 28%. Its cost would be $71,000,000 or $110 per kw., compared to $169 per kw. for a large modern coal-fired plant. Other comparisons follow:

	Atom Fuel	Coal Fuel
Amortization, period	5 yr.	35 yr.
per kw-hr.	2.94 mils	0.65 mils
Taxes and insurance	0.29 mils	0.45 mils
Fuel	0.00 *(a)*	2.37 mils *(b)*
Operation	0.50 mils	0.50 mils
Total electric power cost	3.73 mils	3.97 mils

(a) Cost of fuel to be regained by sale of plutonium. *(b)* Cost of coal is 23¢ per million Btu.

Fig. 2 – Steam Boiler at Experimental Breeder Reactor in Idaho for Taking Heat From Hot Liquid Metal and Generating Steam at 550° F. and 400 Psi. Most of the volume is insulation. (Photo courtesy Argonne National Laboratory)



Liquid Sodium for Coolant

Plutonium Fuel – Metallic uranium was chosen for fuel to minimize the enrichment required and because of the large amount of information on this material. Since undesirable characteristics are associated with the beta phase (alpha transforms to beta uranium at 1230° F.), 1100° F. was chosen as the maximum temperature in the fuel element. Exit temperature of coolant to maintain this minimum is 900° F. Obviously a tubular fuel element which is both internally and externally cooled would result in easier heat transfer and greater heat output than one cooled only on its surface or through a central passage.

The most economical plutonium-power reactor appears to be one using fuel enriched in the fissionable U^{235} isotope. The cost of enriching is more than offset by the reduced unit cost of the plutonium produced. (In general, enrichment results in a higher allowable specific power, a longer permissible irradiation of the fuel, and higher plutonium concentration in the output uranium.) Two methods have been considered for increasing the U^{235} content of the average fuel cell: Either a small uniform enrichment of all the fuel or a "spiking" technique, employing highly enriched uranium in some of the channels.

Sodium for Coolant – Water is the coolant at the Hanford reactors and it exits below 212° F. – not high enough to produce economic power. Therefore a high-temperature coolant was sought about which sufficient data on handling and corrosion were available. Either pure sodium metal or the sodium-potassium eutectic appeared most promising; on these a large amount of data is available from both commercial handling of sodium and from corrosion studies made at several A.E.C. installations.* (Fig. 1.)

As a coolant, sodium-potassium eutectic offers a much lower melting point than sodium and hence a low inlet temperature with a higher possible heat pickup. The alloy remains liquid at room temperatures during a shutdown. However, potassium reacts viciously with the graphite moderator during accidental contact and has a higher neutron absorption. Hence, pure sodium was chosen for a coolant.

Further study indicated the following advantages for sodium over water, even when the latter is pressurized: *(a)* Very high heat transfer, *(b)* high temperature without pressure, *(c)* corrosion resisted by stainless steel containers up to at least 900° F., and *(d)* removal of larger amounts of heat from the fuel elements. The plutonium production is nearly proportional to the heat output of a reactor, and the value of weapon-grade plutonium is so great as compared with electrical power that it becomes necessary to maximize plutonium production. With sodium as a coolant, the optimum temperature is high enough for the practical generation of electrical power.

General Design – The graphite moderator and surrounding 2-ft. thick reflector would be assembled from purified graphite blocks to form an octagonal prism 24 ft. high by 39 ft. across the face. This prism would be provided with cooling channels whose centers are spaced on a square lattice and which contain the tubular fuel elements. Sodium flows both through the fuel elements and the annular space inside the walls of the cooling channel. The hot sodium would flow through a heat exchanger and the cooled metal pumped back to the reactor.

The fuel elements, suitably encased, would be centered in their channels by devices which would not interfere with the flow of the coolant. Retubing would be difficult, but few tubing failures are expected.

Full-load operation will require frequent replacement of fuel element assemblies while operating at full load.

Heat Exchangers for transferring the reactor-generated heat in the sodium to water for steam generation must prevent the accidental contact of sodium and water, and be durable and reliable enough to permit extended operation with little or no direct maintenance because of the radioactivity in the sodium.

To prevent contact and the resulting violent reaction between sodium and water, the heat exchanger would be a shell-and-tube type exchanger with double concentric tubes to provide a barrier space between the two mediums filled with mercury to give good heat transfer and to warn of a tube failure on either the sodium or water side by suitable leak detectors. Figure 2 shows equipment of somewhat different design for transferring heat from liquid metal to water.

Pumps – Both the safety hazards of sodium leaks and the radioactivity of the sodium require the entire liquid-metal circuit to be completely leak-tight (Fig. 1). Ordinary glands or packings are totally unacceptable. Fortunately, a satisfactory seal for valve stems has been achieved by the use of double bellows with

*See also "Liquid-Metals Handbook", 2nd edition, 1952, U. S. Government Printing Office; price $1.00.

a leak detector between the two bellows to indicate failure of the first line of defense. This and other devices are described in "Liquid-Metals Handbook".

Unfortunately, there is no such positive sealing device available for pump shafts. The only leakproof pump now known is the electromagnetic* type; its efficiency is low, and the capacity is such that this reactor will require 15 such pumps (plus spares).

Necessary Preliminary Studies – Since no sodium-cooled reactor has yet been built, the Monsanto-Union group lists many problems which must be investigated. Foremost among them are several metallurgical ones, such as the possible reaction between sodium, either liquid or gas, and graphite under the temperature, radiation, stress, and other conditions which will exist in the proposed reactor.

There is also the question of reaction (carburization and embrittlement) and of the thin cooling channel tubes with the hot graphite moderator. Cracking of the channels would release large amounts of sodium into the graphite. Corrosion and erosion of the element-jackets by sodium in the pile is also one of the critical problems.

The Monsanto-Union engineers note that the radiation damage to materials of construction, components, and mechanisms is important. Although the general problem of analyzing and removing oxygen and other impurities from sodium is being studied at several A.E.C. installations, more needs to be done.

DOW-EDISON'S UNUSUAL PROPOSALS

The report from the Dow-Edison group does not contain specific designs and cost estimates, as do the reports of the other three groups. It is rather a consideration of the various known reactor types and an appraisal of their adaptability to the dual-purpose installation specified by the Atomic Energy Commission. The group concludes that the reactor should be such as to meet several requirements, namely, be self-regulating, use low-cost, uncanned fuel, have a high breeding gain, operate at high temperature (preferably up to 1100° F.), have a built-in plant using some known process for extracting plutonium, and require a minimum plant area from which humans must be excluded for safety – truly a formidable list.

From an economic viewpoint, the net gain in fuel from a breeder reactor promises a margin to offset the high first cost of nuclear reactors as a source of power.

Site: an Anchored Barge

Fuel must be mobile in order to facilitate frequent and rapid processing. Furthermore, a closely integrated processing system must be provided for recovering pure plutonium and extracting fission products. A natural corollary is that the most desirable fuel is one that is liquid at all times, of which several have already been studied:

1. Eutectics of uranium or of plutonium with melting points of approximately 900° F. and higher.

2. Slurries, such as the dispersion of certain intermetallic compounds or alloys of uranium in fusible alloys.

3. Fused salts containing fissionable and fertile metal in solution or suspension.

Much development work is required on any of these fluid-fuel systems and reactors to make use of them.

In order to reduce the cost of exclusion area in populated, industrial areas, the reactor and appurtenances could be built in an existing shipyard on a barge or ship, and then floated out and anchored at a location which provides the adequate safety. "The combination of savings in site location that can be made by this plan and the improvements which appear to be within reach in the reactor and the separations processes offer the possibility that heat delivered to the turbine throttle may be competitive with coal."

Combined Reactor and Refinery – The theoretical reactor that would incorporate the objectives listed at the outset is a fast breeder with a true fluid fuel. The core of the reactor would be all molten metal. It would include metallurgical processing and would not have conventional heat-transfer surfaces. It might be built of refractory materials that would be reasonably good for either thermal-energy or high-energy neutrons.

The fertile material might be either depleted uranium or thorium, depending on the product desired. One primary consideration would be safety. Frequent purification of the fuel metal would keep the toxic and radiation hazards to a minimum. A depleted-uranium or natural-uranium breeder blanket would be used on the outside of the fast-reactor core to produce plutonium. The plant visualized by

*Editor's Footnote – This same principle circulates hot metal in the well-known Ajax-Wyatt vertical ring induction furnaces for melting nonferrous alloys. Many designs of completely sealed pumps for molten metal are described in "Liquid-Metals Handbook", p. 246 e.s.

Common Steel for Handling Helium

the Dow-Edison group would produce 220,000 kw. of heat and (at 30% efficiency for the whole plant) 66,000 kw. of electricity. Coolant would be sodium; its top temperature is limited by corrosion or reaction between sodium and the available piping and containers.

Allowable Cost of Reactor – Based on data for power-plant construction and estimated economics for the new Detroit Edison's St. Clair plant, about 52% of the cost is in steam generation (that is, land, buildings, equipment); of this, the boiler-plant investment represents approximately 20% of the entire investment in electrical and distribution equipment of a 1900-megawatt system. When a nuclear steam generator has been developed to compete economically with present-day boilers, it will not affect the entire electric system investment. Actually, whether steam is generated in a nuclear reactor or in boilers, 80 to 85% of a large utility investment would remain unchanged. Thus, boiler steam-generating plants now in operation would not become obsolete to the extent of requiring immediate replacement with nuclear reactors, as is sometimes believed. It is more likely that the less efficient ones would still be useful in a peaking or a reserve capacity.

A nuclear reactor must be able to supply steam to the turbine throttle for a total cost of less than 59.4¢ per million Btu. to be competitive with present modern boiler generation. Assuming no cost for fuel, labor, materials, and supplies, the Dow-Edison engineers believe that an investment of about $235 per kilowatt of capability would be justified in a nuclear reactor if its design is certain to be economically sound for about 20 years.

COMMONWEALTH-PUBLIC ENGINEERS STUDY TWO POSSIBILITIES

Two extensive studies are described in considerable detail in the Commonwealth-Public report. Both reactors use natural uranium (not artificially enriched in U^{235}) for fuel.

Gas-Cooled Reactor – This is of the "conventional" type, graphite moderated, although it is enclosed in a 44-ft. spherical pressure vessel for reactor and coolant. The latter is helium gas at 10 atmospheres pressure, 450° F. inlet temperature and 742° outlet temperature. The hot helium is circulated through ten boilers to generate steam at 525° F. and 250 psi.

The boilers that absorb the heat from the helium gas are of simple design since the gas contains no ash or incomplete combustion products to deposit on the tubes. The relatively low helium temperature, 650° F., cannot overheat ordinary steel tubes, even though the flow of water may be accidentally interrupted.

In past designs of similar graphite-moderated reactors, the fuel slug has been a cylindrical shape encased in a protective can of high-purity aluminum, but such low-temperature reactors are not suited to the extraction of heat for power.

In the proposed reactor, the fuel slugs have a central hole and external fins which rest on the surfaces of the slug channels in the reactor core. It was assumed that heat is generated uniformly within the volume of the metal, and the design was aimed at uniform heat flow from all parts of the surface. The maximum internal metal temperature is limited to 1000° F. to prevent transformation of the uranium into the beta phase, and to avoid hot spots which might melt the coating.

A proposed new method of coating the fuel elements has passed preliminary tests. The Commonwealth-Public's team observes that an appreciable increase in reactor power could be obtained if an alloy and a method of casing could be found which would permit internal temperatures on the order of 1300° F.

The reactor sphere is to be made of formed and welded 1.67-in. SA 204, grade B, low-alloy steel. Its entire outer surface is sandblasted and then sprayed with a 70% silver, 30% cadmium alloy to reduce the neutron-flux leakage; this treatment is also applied to the helium piping outside the sphere.

Operating at 1000° F. max. in the uranium fuel, such a power plant will cost $40,000,000 exclusive of fuel, and a net of 45,000 kw. will be available to the transmission system. The additional uranium inventory held in the charging area, in cool-off storage, plus a 90-day reserve, amounts to somewhat more than half of the reactor loading. About the same amount of additional uranium is required each year for reactor operation.

D_2O-Cooled Reactor – The helium reactor, briefly described above, was studied first since there was more information available about its various details from the engineering, construction, and operating experience accumulated in existing A.E.C. plants. Consequently it would involve less extrapolation of design data and less time and expense for research and development. Intensive study of a reactor to be moderated and cooled simultaneously by heavy

water (D_2O), as proposed by the Argonne National Laboratory, led to the conclusion that this has better economic possibilities.

This preferred reactor unit is enclosed in a spherical steel shell capable of withstanding 800 psi.; the heavy water is simultaneously the coolant, moderator, and reflector. The fuel assembly is composed of a number of separate units each consisting of several uranium sheets clad with thin metal casings. These fuel assemblies are placed in cylindrical channels. The heavy water returning from the steam generators is deflected by a stainless steel tube sheet into the fuel channels; it then flows upward through and between the channels. The D_2O between the fuel channels acts as the moderator; it travels relatively slowly and discharges from the reactor through the control-rod assemblies.

The reactor core bulks up into a right cylinder contained in the spherical pressure shell. Fuel elements hang vertically in the closely-packed channels and are charged and discharged from the top.

Maximum surface temperature of fuel element is 465° F. when the outlet temperature of the D_2O coolant is 440° F. Therefore, the uranium cladding and the tubes, both located in the reactor core, must withstand these temperatures. When the U^{235} is depleted by about 0.10% of the total fuel weight, the entire fuel assembly is replaced with a new one, requiring a 12-hr. shutdown.

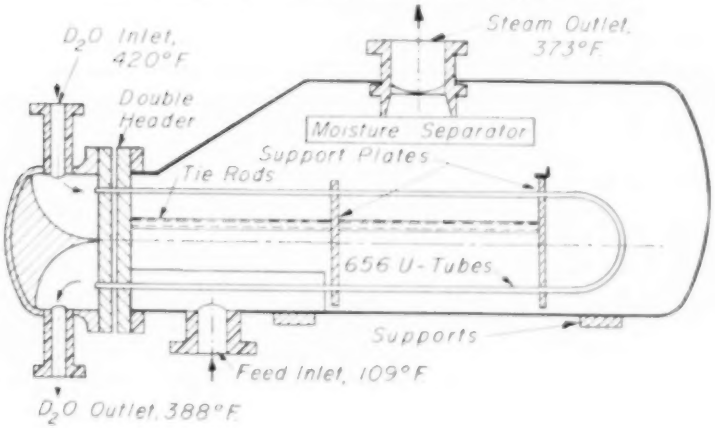
Consideration of the mechanical details and internal pressure resulted in the selection of a spherical shell 2.14 in. thick and 20 ft. 4 in. in diameter, fabricated of Type 347 austenitic stainless steel to prevent corrosion products from contaminating the heavy water. Fuel-element charging tubes, control-rod tubes, water-inlet piping, helium-pressurizing piping, and drain pipe also will be made of austenitic stainless steel.

In order to minimize the amount of heavy water in the system, 18 steam generators (Fig. 3) are mounted in three groups as close as possible to the reactor. The tubes are stainless steel – as are the coolant inlet and outlet boxes. The shell is steel. The tubes are bare. Each set of six generators discharges steam into one of three 80,000-kw. turbogenerators, and the entire installation is housed in a circular building, 217 ft. in diameter (Fig. 4).

Control originates in thermocouples, measuring surface temperature of the fuel elements. (This must be low enough so steam bubbles will not form.) Such temperature readings monitor the supply of heavy water and its distribution. Control rods for regulating neutron flux are sketched in Fig. 5; the rod at left is in "shutdown" position, and the one at right is in "operating" position. The mechanism for moving these rods is mounted below the sphere. It is a linear motor utilizing a magnetic field acting through the nonmagnetic walls of the pressure thimble and positioning a magnetic slug fastened to the bottom of the control rod.

Such a plant as visualized by the Commonwealth-Public team is estimated to cost $118,000,000 and will generate 240,000 kw. (nameplate rating). Approximately 40% of the cost is for the 250 tons of D_2O and 20% is for the reactor, including the D_2O piping system and controls. The remaining 40% approximates the cost of the parallel components of an equivalent conventional steam turbogenerator plant.

Fig. 3 – Cross Section of Steam Generators Proposed by Commonwealth-Public for Reactor Cooled by Heavy Water. Generators are 24 ft. long, 7 ft. 4 in. maximum diameter, and will cost about $80,000 each



These costs exclude costs of the uranium and are based on the assumption that fabricated fuel elements are furnished by others. Each year the additional uranium required amounts to about 10 times the reactor loading. Inventory in cool-off storage, plus reserves, amounts to a somewhat smaller quantity.

The Commonwealth-Public engineers made no economic appraisals of their preferred design, since so many factors are uncertain or unknown, such as obsoles-

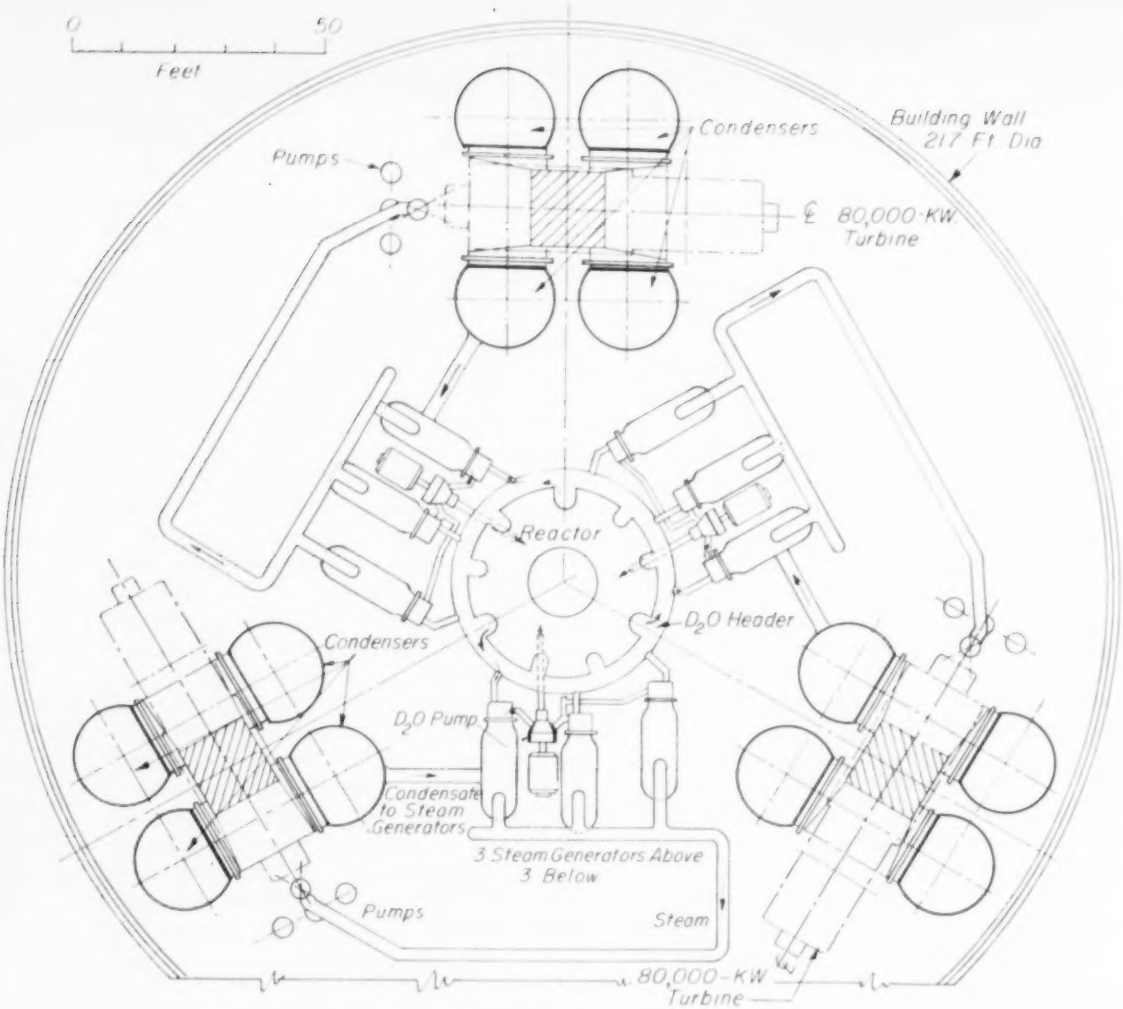


Fig. 4 — General Plan of 240,000-Kw. Power Plant Costing About $118,000,000 or $492 per Kw. of Generating Capacity. (Commonwealth-Public)

cence allowances, and dependence on the Atomic Energy Commission for fuel supply, fuel purification for re-use, the competitive plutonium costs in existing plants, and the amount needed for military purposes. The engineers noted that the design would also be modified if the reactor could operate on enriched fuel, or at a higher temperature, or for a greater "burn-out" of U^{235}, and the "development of corrosion resistant material to permit the higher temperatures and burn-up rates".

PACIFIC-BECHTEL FAVORS A BREEDER

Detailed studies were made by the Pacific-Bechtel team of two reactor types. The first was fueled with 60 tons of natural uranium, moderated with heavy water, and cooled with natural water issuing at 500° F. and 1000 psi.

The exterior piping system of such a plant would be weldable 18-8 stainless steel. Although a low-alloy piping system may be feasible from the standpoint of corrosion, the circulating water would pick up many more metallic ions which would become radioactive in the reactor. Such a "hot" system must be completely canned and the expense would offset that of 18-8 stainless steel piping. The drum and shell side of the heat exchangers are fabricated of carbon steel and designed for an operating pressure of 250 psi. The tube side, however, must be of stainless steel and designed for operating conditions of 1100 psi. and 600° F. The plant would generate 125,000 kw. of electric power.

Commercial Power — However, the above reactor design (about which the minimum of uncertainties now exist) was abandoned by the Pacific-Bechtel team for the breeder reactor using fast neutrons, now under study by the

Knolls Atomic Power Laboratory. This seems to be competitive to the first mentioned in costs of plutonium produced; it has the ability to breed new fissionable material and to operate at high temperatures – both features being desirable in the nuclear-power field, especially the first. Computations indicate that atomic power, having high capital cost and low fuel cost, would be economically justified first where it could operate at a high-capacity factor and earn maximum power revenue. Such power could well be integrated into a large system like Pacific Gas & Electric's, which has a large and rapidly increasing power demand approximately one third of which is base-load power.

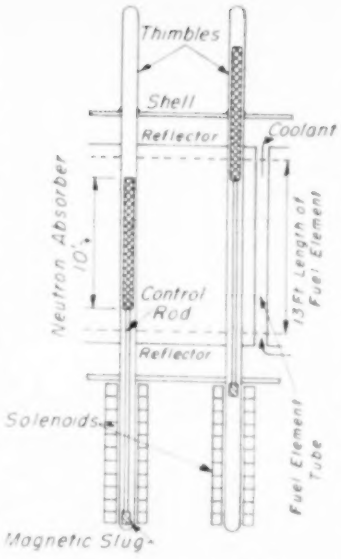


Fig. 5 – Operating Mechanism for Completely Enclosed Control Rods

Breeder Reactor – Furthermore, the fast reactor also appears to have considerable promise for the ultimate nuclear-power industry. This reactor differs from the more-or-less conventional water-cooled type using thermal neutrons in several respects:

1. Since this reactor uses fast neutrons, it can use no materials of low atomic weight to moderate or slow down the neutrons. Therefore, water cooling is precluded, and low-pressure liquid-metal cooling is indicated.

2. Since all materials have much less tendency to absorb fast neutrons at high energy levels, the choice of structural materials is less limited. Stainless steel appears to be entirely suitable.

3. Exposure time can be lengthened and fuel-handling costs thus reduced.

The reactor core of highly enriched material is surrounded by a breeder composed of either depleted or natural uranium. More than 90% of the heat is produced in the core. The core (Fig. 6) consists of an assembly of a large number of fuel elements clad in stainless steel.

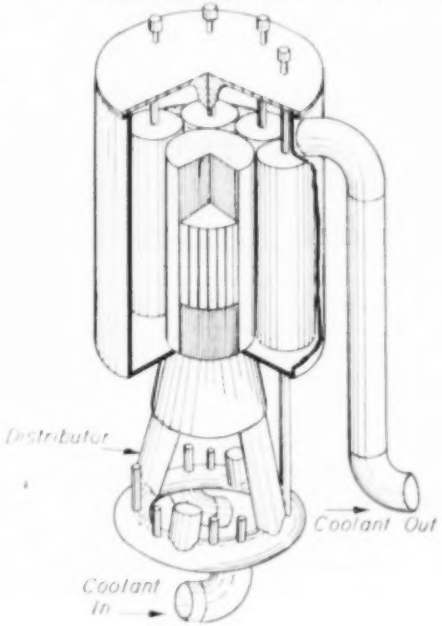
Fuel Elements, Stainless Clad

A reflector will probably be used to envelop this core, serving to decrease the critical mass and also to confine the heat. All the above are to be contained in a cylindrical steel vessel approximately 8 ft. in diameter and 8 ft. high. Provision must be made in the vessel for the circulation of liquid sodium, for access to permit refueling, and for the control mechanism.

Heat is removed from the reactor core and blanket by liquid sodium flowing at high velocity. Circulation is maintained by two electromagnetic pumps. Primary coolant is pumped to two intermediate heat exchangers, entering at 900° F. and returning at 600° F. Heat is transferred from the primary coolant to an intermediate coolant, which is also sodium. This intermediate coolant is circulated to the steam generators, and can be of normal single-tube construction, since leakage of sodium from the intermediate circuit to the primary will not affect reactor operation.

Secondary-coolant sodium entering the steam generators at 850° F. produces superheated steam for the turbogenerators at 500 psi. and 750° F. Steam is delivered to a single large turbogenerator of 154,600 kw. maximum. Although a relatively low-pressure unit, it operates on a conventional regenerative cycle.

Fig. 6 – Diagrammatic Cut-Away of Core Tank for the Sodium-Cooled, Fast Breeder Reactor Favored by Pacific-Bechtel's Engineers



Refueling and replacement of at least a portion of the breeder blanket will need to be done but once a year; the plans call for a month's shutdown for this at a time of low power demand (or flood-time operation of the hydro-electric plants in the system). Refueling is complicated by the requirement that an atmosphere of inert gas (probably helium) must be maintained over the sodium sur-

face at all times. This means that the refueling mechanism must be positioned, the reactor core and blanket exposed, the spent and irradiated elements removed, and fresh elements placed in the reactor without air infiltrating into the coolant space.

Costs – Detailed cost estimates indicate that the site will cost $2,800,000, the reactor (plus sodium but not including fuel elements) $33,100,000, and the turbogenerator plant $15,100,000 – a total of $51,000,000. Operating costs have been estimated on several bases, all for 20-year amortization:

1. Reactor, as designed, making power and breeding fuel: 18.5 mils per kw-hr. (Includes cost of processing spent fuel but no credit for plutonium production.)

2. Reactor as designed, producing power only: 12.5 mils per kw-hr.

3. Same reactor after cost has been amortized: 3.6 mils per kw-hr.

4. Future reactor operating at higher temperatures, after fuel fabrication and refining costs have been reduced 33% by improved technology, operated for power only and integrated into large electrical network: 5.5 mils per kw-hr.

5. Modern conventional steam power plant: 6.0 mils per kw-hr.

These figures indicate that an immediately feasible nuclear-power plant cannot compete with a conventional steam-electric plant. However, if the production of plutonium is the prime requirement, the engineering background is considered to be well enough developed at present to justify proceeding with a program for design and construction. Under the present conditions of plutonium demand and cost, the dual-purpose reactor will have continuing economic value solely as power producers after the plutonium demand is over.

The Pacific-Bechtel group therefore recommends that the development and design of a fast breeder with solid fuel elements, cooled with liquid metal, be undertaken promptly.

Fig. 7 – Scale Model of Proposed Pilot Plant for 8000 Kw. of Electric Power. Chauncey Starr, director of North American Aviation's atomic energy research department, points to the reactor foundation; above the reactor is a compartment housing the control-rod mechanism; to its left is the instruments and operations center. Heat interchangers are underground (center). Turbogenerators and electrical delivery system are at right, as is also J. H. Kindelberger, chairman of North American's board of directors. President J. L. Atwood is at the rear



FOOTNOTE – Late in May, after the report of the four power groups was declassified by the Atomic Energy Commission, North American Aviation, Inc., issued a press release inviting other industrial firms to share in building a $10,000,000 pilot plant to produce 8000 kw. of electric power. This is to be a single-purpose plant – that is to say, its objective is to produce power only. Liquid metal (nature unspecified) would carry heat from reactor to a water boiler, and the latter would generate steam for a turbogenerator. Details of the design were not disclosed, although the general plans and estimates will be opened to any responsible person with proper security clearance. A photograph of what is said to be a scale model (Fig. 7) shows a reactor of comparatively large size, indicating that either natural or slightly enriched uranium will be the fuel. It is admitted by North American's engineers that the cost of producing electricity from atomic fission is now higher than by conventional methods, but it is necessary to build pilot plants to establish future designs for competitive central stations. The present design is one result of a 1948 contract between Atomic Energy Commission and North American Aviation to study the general field of reactor technology.

Conclusions – One important conclusion which the reader (who in all likelihood is not a specialist in power-plant engineering) may reach from the entire document, so briefly summarized in this article, is that none of the four groups of engineers and executives are pessimistic. The Commonwealth-Public team even includes time schedules showing trial operation starting within four years after authorization to build.

Another conclusion is that so many possibilities have been found worthy of study that each group decided independently upon a main design different from that of any of the others.

Finally, the Atomic Energy Commission's Advisory Committee on Industrial Information reminds the reader that, from long familiarity with existing plants and thermodynamic cycles, power engineers assume that nuclear-power plants will have to operate on the same high-temperature, high-pressure steam cycles which characterize modern fuel-fired plants. The reports indicate that this is not so. All plans involve the use of conventional steam turbines supplied with steam from heat exchangers (boilers), which in turn are supplied with heat from the coolant flowing through the nuclear reactors. In only one does the design of these plants involve steam at a pressure higher than 500 psi. or at temperatures above 750° F. – far below what would be expected in a central-station steam plant today. However, with further development of reactor materials which have both desirable nuclear properties and ability to withstand higher temperature and pressure, it may be possible to take advantage of smaller turbine investment and improved thermal efficiency that result from increased temperature and pressure.

Here is where the metallurgist will come in.

Correspondence

Steels for Extrusions

LONDON, ENGLAND

Although experience in large-scale production of steel extrusions is still largely confined to low-carbon materials of deep drawing qualities, some knowledge of the use of higher carbon and alloy steels has recently become available, and further development of techniques for extruding these may be speeded by the need to utilize the properties of the latter group. This was the opinion expressed by D. V. Wilson, University of Birmingham, England, in his talk on metallurgical requirements of steels for extrusions which he presented at the symposium on cold extrusion of steel sponsored by the Sheet and Strip Metal Users' Technical Association, and held during the past month in London.

The reason for the preference for these soft homogeneous materials, said Dr. Wilson, is partly due to their low work hardening capacity which makes them particularly suitable for cold extrusion, and partly because excellent strength properties may be developed in low-carbon steels as a result of the high deformations attained in the process.

In a summary of his views, Dr. Wilson stated that the majority of applications of cold extruded steel in the immediate future will probably use low-carbon steels of deep drawing quality. Nonaging steels, low in impurities, may offer worth-while advantages when service requirements are severe. Promising results have also been obtained with low-carbon steels, but further development work is required. The extension of cold extrusion to higher carbon steels is to some extent limited by tool strength and tool wear. Nevertheless, an outstanding advantage in other directions may lead to further development of techniques for dealing with high-carbon steels. For example, the extrusion of a component in a soft condition followed by induction heat treatment – a technique already applied to deep drawn shell cases – could prove to be an economical method of production for some items.

TOM BISHOP

Silicon for Transistors

PHILADELPHIA

The statement made in the article, "An Appraisal of Silicon and Its Alloys" (*Metal Progress* for February 1953) that the actual quantity of silicon which might be used for transistors and crystal *(Continued on p. 110)*

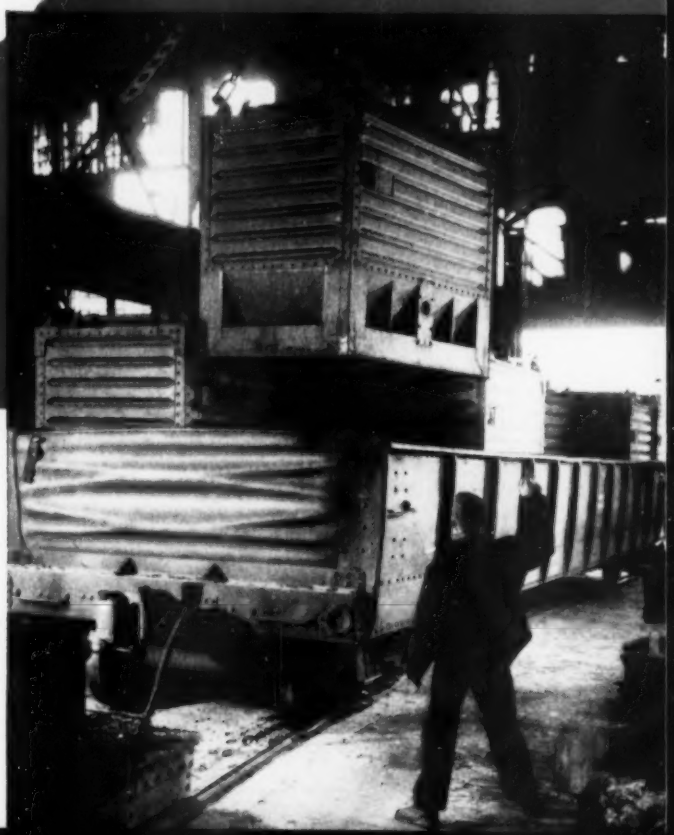
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Pellets shown approximately 3/4 actual size.



1 EASY TO HANDLE

SIMPLEX pellets are usually shipped in bulk in container cars. Each container holds up to 10,000 lb. of material. As many as 12 containers, holding a total of 56 tons, can be shipped in one car. This makes it easy to handle large quantities of ferrochrome fast and economically, and prevents contamination.

The terms "Electromet" and "Simplex" are trademarks of Union Carbide and Carbon Corporation.

SIMPLEX ferrochrome is a new chromium alloy specially developed by Electro Metallurgical Company to simplify the production of stainless steel. The alloy is suitable for producing all grades of stainless steel and is specially adapted for the extra-low-carbon grades.

Outstanding advantages of SIMPLEX ferrochrome are its extremely low carbon content and surprisingly rapid solubility. These characteristics make it possible to reduce furnace time substantially, and to obtain a consistently high recovery of chromium together with a high metallic yield.

SIMPLEX ferrochrome is uniformly sized. It is produced in the form of pellets about the size and shape of a walnut. It contains about 65 per cent chromium and about 6 per cent silicon. The carbon specification is 0.025 per cent maximum. Maximum 0.010 per cent carbon can be furnished.

For additional information phone, wire, or write one of the ELECTROMET *offices. Ask for the* ELECTROMET *booklet entitled, "Melting Low-Carbon Stainless Steel." It shows the advantages that can be obtained in producing low-carbon stainless steel with* SIMPLEX *ferrochrome.*



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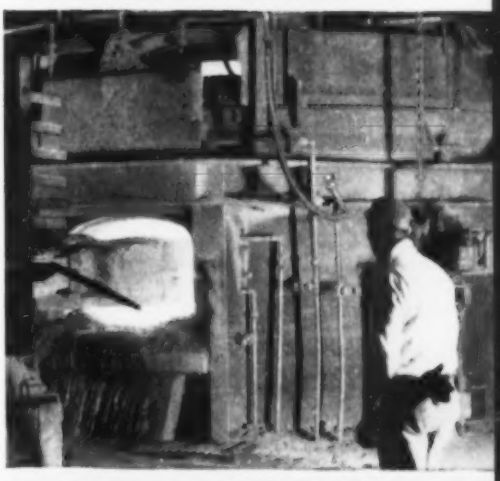
2 LOW CARBON CONTENT

Here is the new SIMPLEX ferrochrome ready for charging in the production of a heat of extra-low-carbon stainless steel. The carbon content of the pellets is so low that the addition of SIMPLEX ferrochrome will not increase the carbon content of the bath.



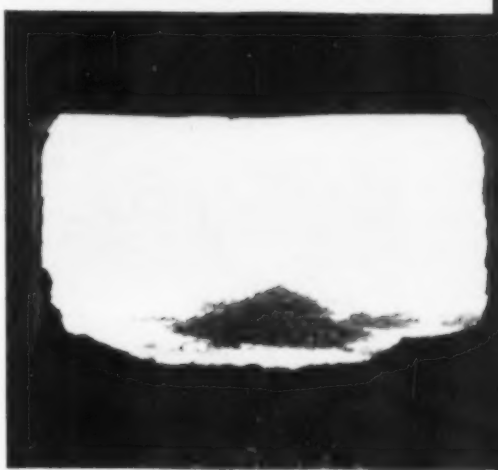
3 FAST SOLUBILITY

A charging machine dumps a loaded box of SIMPLEX ferrochrome in the bath. Because of the speedy solubility of the alloy in pellet form, as much as 15,000 lb. of SIMPLEX ferrochrome can be added to the furnace in one batch.



4 REDUCES FURNACE TIME

The alloy pellets dissolve in the bath more readily than does conventional lump ferrochrome. As much as 45,000 lb. of SIMPLEX pellets can be dissolved in slightly more than one hour. This means reduced furnace time.



5 HIGH METALLIC YIELD

The metallic yield averages about 90 per cent when SIMPLEX ferrochrome is used, since the alloy contains enough silicon to reduce metallic oxides in the slag back into the bath. Overall chromium recoveries of 90 to 95 per cent are obtained regularly.



Correspondence

(Continued from p. 107) rectifiers would be extremely small compared to its over-all use as an alloying and deoxidizing agent is quite correct. However, when one considers that the price of pure silicon for semiconductor use is as high as $450 per lb., an annual market for a few thousand pounds is a rather large one for a company of our size; actually, the market could be very much larger.

The sentence on page 107, "Furthermore, germanium has now largely replaced it (silicon) in this particular field", is not quite correct. It is true that the original diodes made for electronic use were made mostly from silicon by the Sylvania Electric Corp., whereas now most of the diodes or transistors or any other of these similar electronic devices are of germanium.

However, there is one other point – and a very important one – to consider; namely, that germanium is very limited in its use, particularly at elevated temperatures. Therefore, when silicon can be made available in the proper purity and in the proper quantity, it will probably replace germanium almost 100% in certain applications and thereby greatly widen the use of semiconductors of this type for severe services.

I believe these statements can be confirmed by any of the large companies now doing transistor development or production work: Bell Telephone Laboratories; R.C.A. Laboratories; Raytheon Manufacturing Co.; Hughes Electronics; and, of course, the Signal Corps at Squier Laboratory, Fort Monmouth, New Jersey. All of these organizations are working on silicon semiconductors.

Actually, the article is completely accurate up to the point where the future of silicon in electronics applications is discussed; it appears that the trend will be reversed and silicon probably will replace germanium to a large extent in the future.

W. M. Raynor, Manager
Special Product Sales, Foote Mineral Co.

Welding Congress in Spain

Madrid, Spain

The Third National Assembly of the Institute of Welding will be held in Madrid during October 1953. Invitation is extended to attend the exposition of welding equipment and supplies, and to submit papers for presentation at the assembly. Admission is open to papers devoted to the following themes: Gas welding, arc welding, resistance welding, inspection and testing, stress relieving, hygiene and safety, weldability, residual stresses, fracture sensitivity, fatigue testing, teaching of welding, and design and fabrication of welded structures and their cost evaluation. Closing date for the papers is September 25, 1953.

Additional information may be obtained from the Instituto de la Soldadura, Comisión Organizadora de la III Asamblea, Goya 58, Madrid, Spain. Visitors from United States and Canada are especially welcome.

Manuel de Miró Ramonacho
for the Commission on Organization
Instituto de la Soldadura



When Cicadas Hit Baltimore Even Fractures Have Bugs

Baltimore, Md.

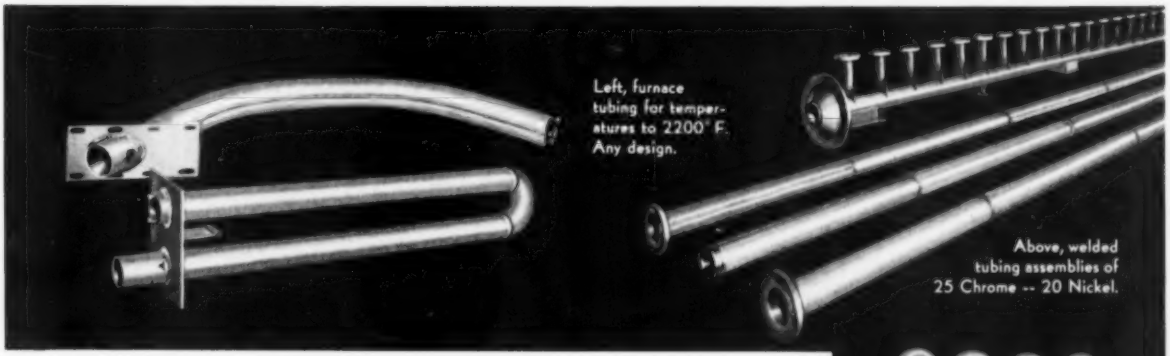
Since 1936 approximately 30,000 *Tibicen pruinosa* larvae per acre in the Baltimore area have been progressively passing from the diaper stage through grass-roots education in our kinder's garden, through fly school and collitch, finally right through our foliage in 1953! These are the phenomenal "17-year locusts", thus misnamed. A conservative estimate of the crop on my 5-acre plot alone is 150,000 large whirring bugs. At 50 to the pound, that will be 1½ tons of natural fertilizer in July – if they don't fly over to my neighbor's yard to die.

While staring thru the 'scope one day
In the merry, merry month of May
To my very great surprise
I saw a pair of eyeballs . . . . . .

However, it was just a fracture traverse through a plastic hair-comb (Read's Drug Store). Cyclic flexing established a pair of fracture foci at opposite lateral ribs, which then spread more or less simultaneously to force the pattern of the accompanying macrofractograph, at 3.5 ×.

Carl A. Zapffe
Consulting Metallurgist

(More Correspondence on p. 112)



Left, furnace tubing for temperatures to 2200° F. Any design.

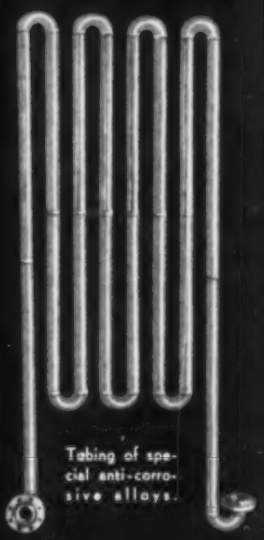
Above, welded tubing assemblies of 25 Chrome -- 20 Nickel.

Cut Your Tubing Costs 3 Ways with PSC 'Thin Wall' Construction

Some customers have found that PSC heat and corrosion-resistant tubing has cut their costs over 50%. Take for example a company which had been using 3" tubing of standard I. P. S. .216" wall thickness, on an application where pressure and erosion were low, but temperature and corrosion conditions were constantly troublesome. They installed PSC tubing of only 16 gauge (1/16" section) but of a metal analysis suited to solve their troubles. The saving in metal in this case was over 71%. At the cost of alloy steels, this was very substantial. But this customer saved two other ways also: In the lower fabricating cost of light gauges. And in the less labor and material required to install PSC light-weight welded alloy tubing. The replacement saving is impressive. Specializing in precision fabrication of complex tubing assemblies, PSC furnishes tubes for all types of radiant furnaces, and for furnace externals such as vent stacks for exhausting fumes. Fabricated in any diameter up to 60" and in any alloy.



Send for **HEAT TREATING CATALOG 52**



Tubing of special anti-corrosive alloys.



PSC light-weight welded alloy tubing facilitates construction problems in handling gases.

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Vycor Vs. Silica Heat Treating Tubes

CAMBRIDGE, MASS.

In an effort to prevent contamination of highly reactive metals (such as titanium, zirconium and others) with the atmosphere, it is common to use sealed Vycor and silica tubes which may either be evacuated or filled with an inert gas. Some of their limitations with respect to time, temperature, and atmosphere were determined by the writer and C. C. Wang (formerly research assistant at M.I.T., now Sylvania Electric Products Inc., Ipswich, Mass.). All of the tubing was of 17 mm. o.d. and 1 mm. wall thickness.

VYCOR TUBING

Evacuated – Withstood 900° C. (1650° F.) for more than two days, 1000° C. (1830° F.) for more than 12 hr., and 1100° C. (2010° F.) for about ½ hr. At 1200° C. (2190° F.) it collapsed within a few minutes.

Helium Atmosphere – (Presumed to provide an internal pressure of one atmosphere at the annealing temperature.) At 1200° C. the tube was good for about ½ hr., but collapsed within a few minutes at 1300° C.

Argon Atmosphere – At 1200° C. the Vycor lasted for more than 17 hr. and at 1300° C. (2370° F.) for more than 9 hr.

SILICA TUBING (CLEAR, VITREOUS)

Evacuated – Silica withstood 1400° C. (2550° F.) for 20 min. before collapsing, but collapsed quickly at 1450° C. (2640° F.).

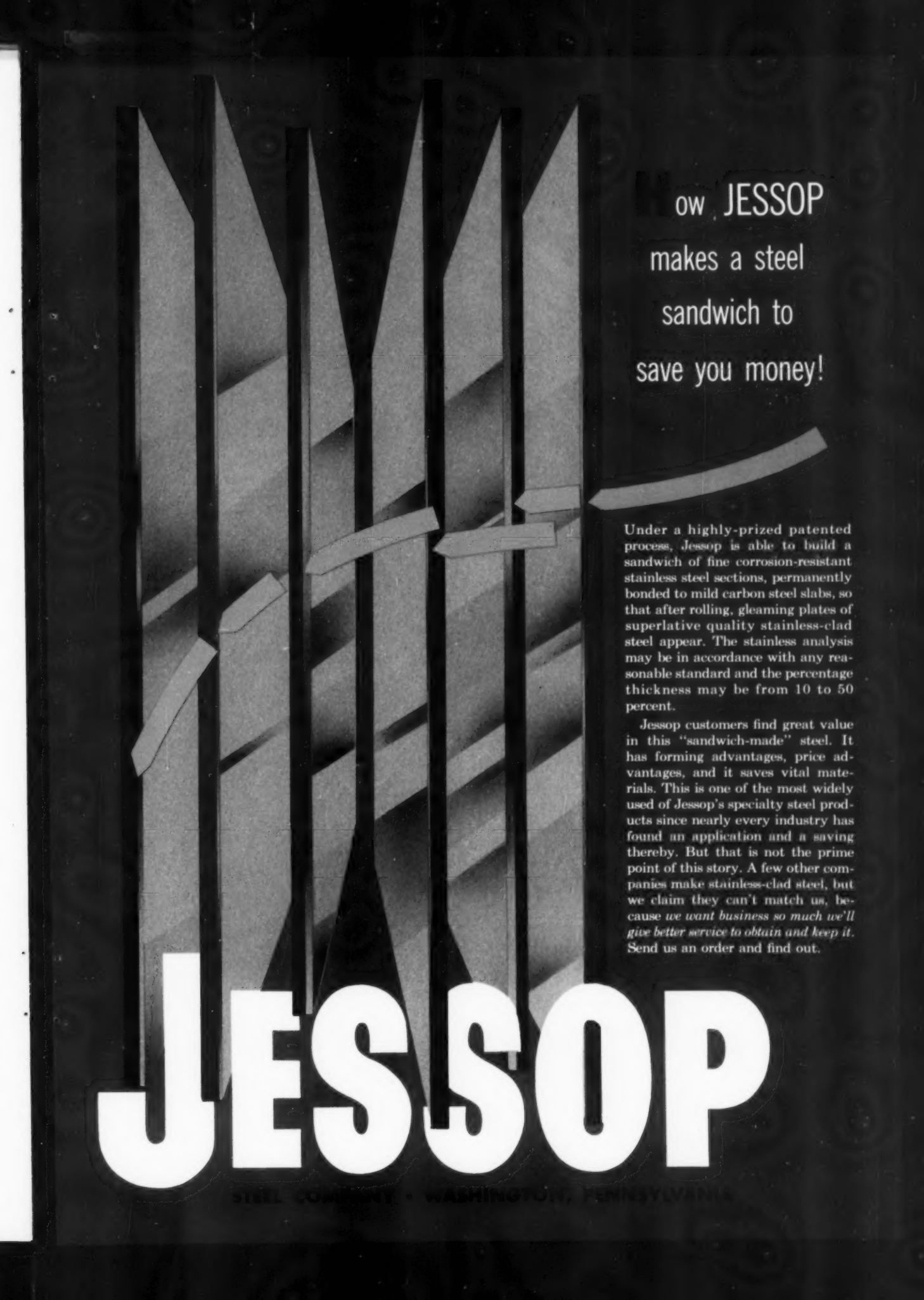
Helium Atmosphere – The tubing withstood 1450° C. for about 20 min., but collapsed at 1500° C. (2730° F.) in less than 15 min.

Argon Atmosphere – The tubing withstood 15 hr. at 1400° C., 4 hr. at 1450° C., and was useful for almost 3 hr. at 1500° C.

These results would indicate that the use of argon, as compared to helium or vacuum, permits appreciably longer working times at higher temperatures. The results also suggest that helium is probably escaping through the tubing walls at these high temperatures.

NICHOLAS J. GRANT

Assoc. Prof., Dept. of Metallurgy
Massachusetts Institute of Technology



How JESSOP makes a steel sandwich to save you money!

Under a highly-prized patented process, Jessop is able to build a sandwich of fine corrosion-resistant stainless steel sections, permanently bonded to mild carbon steel slabs, so that after rolling, gleaming plates of superlative quality stainless-clad steel appear. The stainless analysis may be in accordance with any reasonable standard and the percentage thickness may be from 10 to 50 percent.

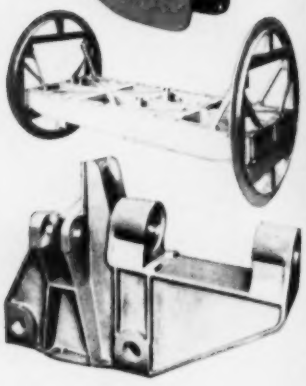
Jessop customers find great value in this "sandwich-made" steel. It has forming advantages, price advantages, and it saves vital materials. This is one of the most widely used of Jessop's specialty steel products since nearly every industry has found an application and a saving thereby. But that is not the prime point of this story. A few other companies make stainless-clad steel, but we claim they can't match us, because *we want business so much we'll give better service to obtain and keep it.* Send us an order and find out.

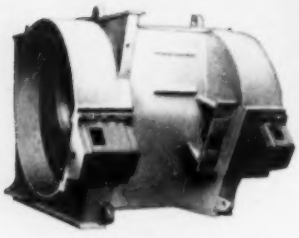
JESSOP

STEEL COMPANY • WASHINGTON, PENNSYLVANIA

Steel-Weld FABRICATION



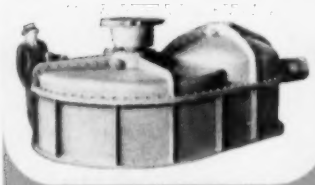














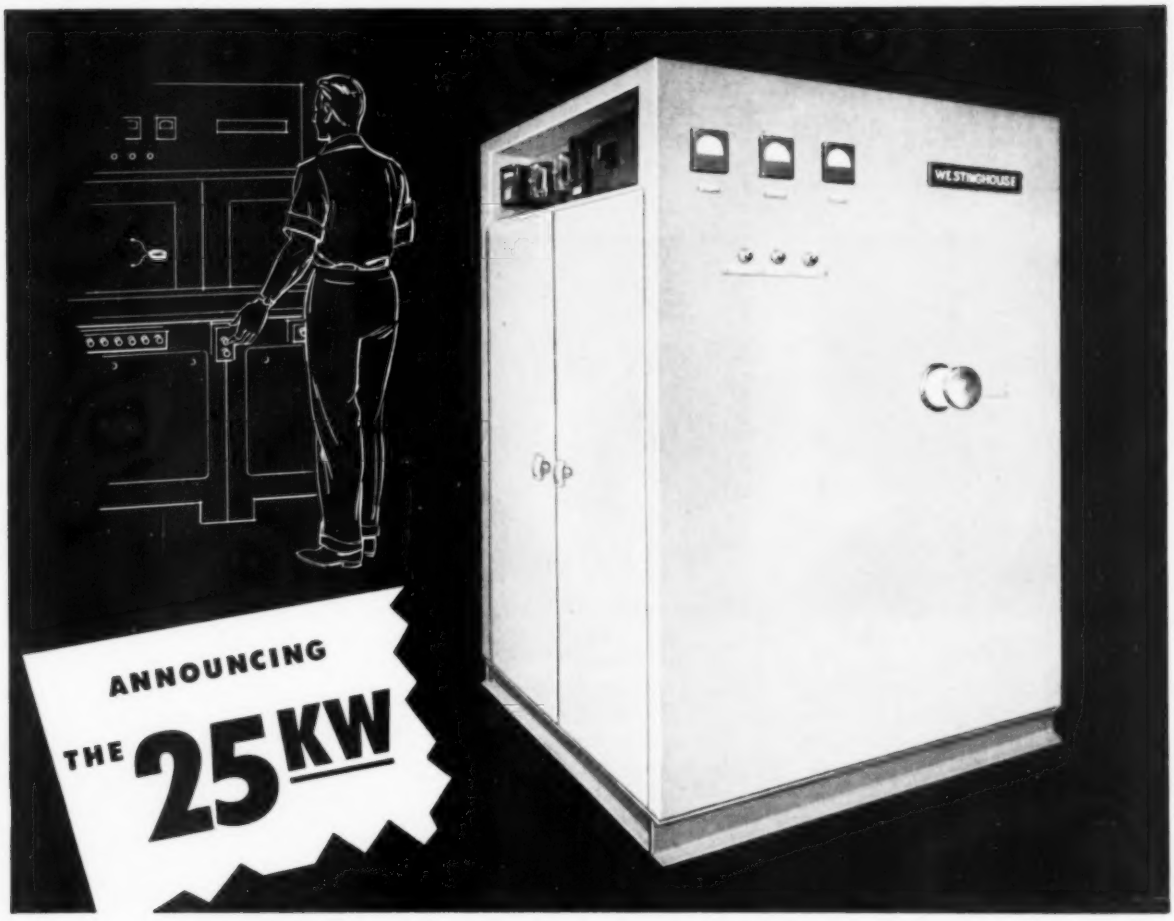
Use WELDED STEEL for Greater Strength with Less Weight!

Illustrated above is a twenty-two ton Moving Cross-Head for a 2500 ton Press. This and other units illustrated at the left are typical of thousands of Steel-Weld Fabricated parts and assemblies produced and machined by Mahon for hundreds of manufacturers of heavy machines and equipment. If parts of your product could be redesigned and produced to better advantage through Steel-Weld Fabrication, or, if you require a limited number of large heavy pieces, in which pattern costs are a consideration, you can turn to Mahon with complete confidence . . . personnel and facilities are available within the Mahon plant to do the complete job from drawing board to finished machining. You will find in the Mahon organization a unique source with complete ultramodern fabricating, machining and handling facilities to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Mahon's Insert in Sweet's Product Design File, or write for further information.

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NEW HF GENERATOR PUTS FULL POWER

EVEN INTO LOOSE-COUPLED COILS AND NON-FERROUS LOADS

Westinghouse now presents a new high-frequency generator with 25 KW output at 100% duty cycle. For optimum performance, the new 25 KW has a tank kva of 1620. This means you can now put full power into a wider variety of loads . . . even where close coil coupling is impractical. Non-ferrous materials, like brass, copper and aluminum, can be heated in much shorter time. You benefit in higher production rates at lower costs.

This latest addition to the Westinghouse line of induction heating tools has many more outstanding benefits. Here are some of them:

- Allows positive, precise heat control of short production runs on a variety of jobs . . . or long production runs with rapid heat cycles. The built-in electronic keying of power output that makes this possible also eliminates main contactor arcing.
- Provides smooth variation of power output from 25% to 100%. This simplified power output system utilizes dependable, maintenance-free saturable reactors and longer-life, cost-cutting diode rectifier tubes.
- Gives complete protection against condensation and water-impurity troubles. The built-in distilled water cooling system and heat exchanger offers substantial raw water economy, too.
- Assures long tube life, peak performance and minimum maintenance by close regulation of filament voltages.
- Offers easy inspection and maintenance through the full-opening double doors; easier operation through a simplified combination of conveniently located controls.

The new Westinghouse 25 KW RF Generator is available now in this de luxe model. A standard model is also available with electronic keying and smooth power output control features as easily-installed optional accessories. Both models offer flexible, economical handling of hardening, annealing and metals-joining jobs. For full information write: Westinghouse Electric Corporation, Electronics Division, Induction Heating Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

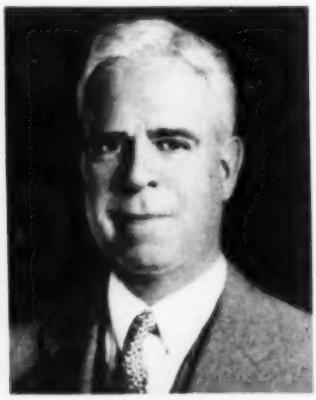
YOU CAN BE SURE...IF IT'S **Westinghouse**

J-02270

Personal Mention



F. E. Wormser



A. E. White

In a White House ceremony, FELIX E. WORMSER was sworn in as assistant secretary of the Department of the Interior, with President Eisenhower as an interested witness. As assistant secretary for mineral resources, he will have supervision over the Bureau of Mines, the Geological Survey, Division of Geography and the Division of Oil and Gas.

Mr. Wormser was born in Santa Barbara, Calif., in 1894, and received a degree in mining engineering from Columbia University in 1916. He was employed as an engineer by the Bureau of Mines, Department of Interior, in 1919. At one time he served on the editorial staff of the McGraw-Hill Publishing Co., Inc., New York, and for several years was engaged in private industry as a construction mining engineer. In 1947 he became secretary-treasurer of the Lead Industries Association in New York, later becoming vice-president of St. Joseph Lead Co.

Mr. Wormser is a veteran of World War I. He served on the Munitions Board (nonferrous metals), and was a member of primary lead producers' industry advisory board of the War Production Board during World War II. He is a member of the American Institute of Mining and Metallurgical Engineers, Society of American Military Engineers, and is co-author of the book "Marketing of Metals and Minerals".

"COLONEL" WHITE is remembered by all old-time members of the American Society for Metals as the man who viewed the competition between two aspiring groups – the American Steel Treaters' Society with headquarters in Chicago, and the Steel Treating Research Society centered in Detroit – as strictly wasteful and did something about it: They were amalgamated in 1920 into the American Society for Steel Treating, and in token of his effective skill as arbitrator he was elected first president. His interest in Society affairs has been continuous – only an overwhelming event would keep him from the annual conventions.

Albert White is remembered by thousands of University of Michigan alumni as a good teacher and wise advisor. He joined the faculty of the department of chemical and metallurgical engineering in 1911, and has been there ever since – barring wartime leaves for national service. During the first World War, plans were made by Michigan manufacturers and the University's Board of Regents for a "Department of Engineering Research", and Prof. White was made director by unanimous action. The scope of its activities has continuously increased and in 1948 the name was changed to "Engineering Research Institute". Despite his administrative and teaching duties, A. E. White has devoted so much time to high-temperature metals for power plant use that he has become the foremost American authority in that branch of metals engineering.

All these men – ASMembers and Wolverines – will wish Albert White long life and much happiness at the beginning of his terminal leave from the University, which takes place this summer.

Frank C. Brautigam, who was previously employed as chief metallurgist of Fasco Industries, Inc., Rochester, N. Y., has been appointed chief metallurgist of the U. S. Hoffman Machinery Corp., Scranton, Pa.

William S. Richmond, formerly with the J. I. Case Co., Bettendorf, Iowa, is now employed as junior foundry engineer with the Pacific Cast Iron Pipe & Fitting Co., South Gate, Calif.

J. B. English has been appointed chief plant metallurgist of the McCook Sheet Mill Operations of Reynolds Metals Co., McCook, Ill. He was formerly director of the metallurgical and pilot research laboratories of the company at Richmond, Va.

F. D. Radcliffe, formerly eastern materials representative, is now district materials coordinator for Standard Oil of California and resides in San Marino, Calif.

Charles E. Reardon, service metallurgist for U. S. Steel Corp. at Chicago, is now in Washington, D. C., as consultant to the Metallurgical and Conservation Branch of the National Production Authority. Mr. Reardon, who has been an member since 1926 and has served on the executive committee of the Chicago Chapter, is serving his second term with N.P.A. in two years.

Kirk Q. Buddington, Jr., has received a B.S. degree in metallurgical engineering from the University of Michigan, and has accepted a position with the American Brake Shoe Co., New York.

Warren L. Wright, formerly with Bridgeport-Lycoming Division, Avco Mfg. Co., Stratford, Conn., is now senior spectrographer in the metallurgical research laboratory of Jones & Laughlin Steel Corp., Pittsburgh.

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2. The Revere Technical Advisory Service was established by Revere over 20 years ago, as a nation-wide organization whose duty it is to collaborate with engineers, designers and production men, seeking ways to solve problems, cut costs, improve products, or all three.

3. The Revere Research Department operates a laboratory, staffed by engineers and scientists, and equipped with the latest scientific apparatus, including the spectrograph and X-ray diffraction. This Department is called upon by salesmen and Technical Advisors when they find it necessary to obtain thorough physical and chemical analyses, and base their recommendations upon such findings.

4. The Revere Mills, located in industrial centers from coast to coast, are an integral part of our organization, collaborating closely with the other three services. They give you exactly what you require, as to alloy, size, gauge, temper, finish, and their experience is often invaluable in helping to solve tough problems.

Please note that this four-way service, originated by Revere, does not take the place of your own engineers, designers or production men. It collaborates with them, confidentially. There is no charge or obligation. To obtain this service, get in touch with the nearest Revere Sales Office.

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COPPER ★ BRASS ★ ALUMINUM

Personals

George K. Dreher ⊕, formerly executive director of the Foundry Educational Foundation, Cleveland, has joined Waukesha Foundry Co., Waukesha, Wis., as manager of the casting division and a director of the firm.

Lawrence R. Foote ⊕, formerly a member of the New York Chapter, has moved to Cleveland to become vice-president of the newly organized Bryant Industrial Products Corp.

Marion Lewis Picklesimer ⊕, from the University of Tennessee, has been appointed to the staff of Oak Ridge National Laboratory, Oak Ridge, Tenn.

O. W. Reen ⊕ recently received his doctorate in philosophy from Rensselaer Polytechnic Institute, and has accepted a position as research metallurgist with the Carmet Div. of Allegheny Ludlum Steel Corp., Ferndale, Mich. Dr. Reen was formerly on the staff at Rensselaer Polytechnic Institute as research associate in the metallurgy department.

Albert Muller ⊕ has been appointed director of metallurgical research by Air Reduction Co., Inc., Murray Hill, N. J. He had served as manager of the metallurgical division since 1951. A native of Wading River, N. Y., Dr. Muller received his formal education at the Rensselaer Polytechnic Institute where he obtained his bachelor's and master's degrees in electrical engineering and a Ph.D. in metallurgy. While at R. P. I. he held the International Nickel Co. Research Fellowship in metallurgy. During World War II he was research supervisor for the National Academy of Sciences, War Metallurgy Committee. Dr. Muller joined the Air Reduction Research Laboratories in 1946 as head of the welding section. In his new position he is responsible for the company's research activity in combustion, physical metallurgy, welding, process metallurgy, instrumentation and thermochemical products.

Dr. Muller is a member of the American Institute of Mining and Metallurgical Engineers, Iron and Steel Institute, Institute of Metals, American Welding Society and the American Ordnance Association.

Hugh D. Luke ⊕ has been appointed manager of the manufacturing department of Reliance Electric and Engineering Co., Cleveland. Mr. Luke brings nearly 20 years of diversified experience in the industrial engineering field to his new post. A chemical engineering graduate of the University of Cincinnati, he was associated for 10 years with the Andrews Steel Co., Newport, Ky. He spent two years as a naval officer with the amphibious forces in the Pacific area. He joined the engineering staff of Schenley Distillers Corp., Cincinnati, in 1940 and later became plant engineer of the company's Taunton, Mass., plant. He left the following year to accept the plant managership of the Mount Hope Machinery Co., in Taunton. He was at McKinsey and Co., Boston, for the past six years.

H. J. Huester ⊕ has been transferred from the Naval Aviation Supply Office, Philadelphia, to the overhaul and repair department, Naval Air Station, Jacksonville, Fla. A member of the ⊕ for 30 years, Cdr. Huester is now active in obtaining memberships and a formal petition to organize a Jacksonville Chapter.

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by Eliminating { STAINING, DULLNESS, RUSTING and difficult cleaning problems

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CLEANING — When 1 oz. of MAGIC DRY is added to your alkali cleaner, vapor degreaser, or solvent cleaner, many difficult cleaning problems become a matter of routine.

HERE ARE 4
additional, new, proven products that will increase production and reduce costs!
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MAGICLENE #2 — Rust preventative, rust remover, cleaner and paint base.
BLACK MAGIC S.S. — Black finish for stainless steels, cast and malleable irons.
PIK-AIDE—Pickling addition agent.
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Title _____

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Personals

A. B. Lawrason has resigned his position as president and general manager of Eureka Foundry & Mfg. Co., Ltd., to become president and general manager of Woodstock Machinery, Ltd., Woodstock, Ont. He retains his place on the board of directors of the former firm.

Charles J. Conforti has been appointed regional sales manager of the west central region of the Detrex Corp. of Detroit.

Saul E. Bramer has resigned as metallurgist with the California Research and Development Co. to become metallurgical research analyst for Menasco Mfg. Co., Los Angeles.

Donald P. Marquis, formerly product engineer at the Michigan plant of Thompson Products, Inc., is now staff engineer in the Steering Gear Division, General Motors Corp., Saginaw, Mich.

S. Robert Simonds has been appointed Seattle (Wash.) manager of A. Milne & Co., New York.

Henry von Blohn has been transferred to the fabricating division of the Bethlehem Steel Co.'s Steelton (Pa.) Works. He was formerly research engineer at the company's main plant.

Lathan C. Jackson, formerly process engineer with Temco Aircraft Corp., and its subsidiary, Luscombe Airplane Corp., Dallas, Tex., recently accepted a position as laboratory supervisor for the oil tool division of Chicago Pneumatic Tool Co., Ft. Worth, Tex.

James R. Berens, who recently graduated from the University of Cincinnati, has joined the staff of Republic Steel Corp., Canton, Ohio, as a laboratory metallurgist.

Harold N. Bogart, who is associated with Ford Motor Co., Dearborn, Mich., as supervisor in the metallurgical unit of the manufacturing research department, has been elected as one of 34 Sloan Fellows for advanced study in the field of executive development at Massachusetts Institute of Technology.

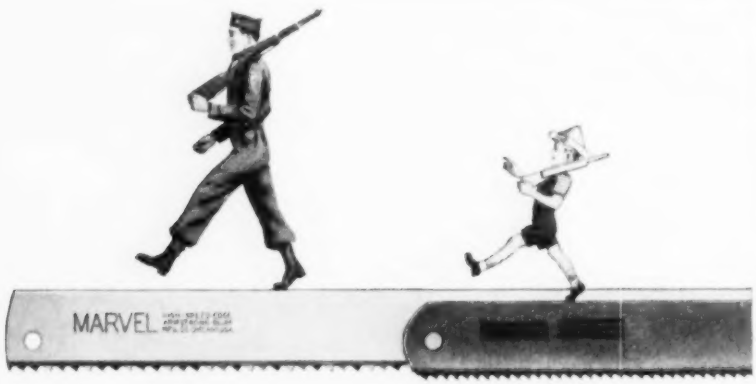
A. L. Walters has resigned from Battelle Memorial Institute, Columbus, Ohio, and accepted a position as metallurgical engineer with Phillips Petroleum Co., Bartlesville, Okla.

Robert J. Johnson has resigned as plant maintenance and research metallurgist with Republic Steel Corp., Canton, Ohio, to accept a position as chief metallurgist for Round Chain Co., Cleveland.

Frank R. Yurkoski, Jr., accepted a position with the General Laboratories of the American Car & Foundry Co., Berwick, Pa., after graduating with a B.S. degree in metallurgy from Pennsylvania State College.

Raymond B. Ziccarelli has resigned his position as metallurgical engineer at Boeing Airplane Co., Seattle, Wash., to accept employment at Ford Motor Co., Aircraft Engine Division, Chicago, as material review representative, quality control department.

Fred G. Campbell has resigned as service metallurgist with U. S. Steel Corp., Pittsburgh, to accept a position as metallurgical engineer, bars and sheets department, Kaiser Steel Corp., Fontana, Calif.



. . . but

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More than a quarter-century ago MARVEL invented and basically patented the MARVEL High-Speed-Edge Hack Saw Blade—the UNBREAKABLE blade that increased hack sawing efficiency many-fold.

Every MARVEL Hack Saw Blade ever sold has been of that basic welded high-speed-edge construction, with constant improvements from year to year, as EXPERIENCE augmented the "know-how" . . .

MARVEL is not "tied" to any single source of steel supply, and has always used the best high speed steels that became available from time to time as metallurgy progressed. When-as-and-if finer steels are developed—and are proven commercially practical for welded-edge hack saw blades—MARVEL will use them, regardless of cost or source . . .

There is only one genuine MARVEL High-Speed-Edge! All other "composite" or "welded-edge" hack saw blades are merely flattering attempts to imitate—without the "know-how" of MARVEL EXPERIENCE . . .

Insist upon *genuine* MARVEL High-Speed-Edge when buying hack saw blades—and be SAFE, for you can depend upon MARVEL. They have been "tested", "pre-tested", and "re-tested" by thousands of users for more than a quarter-century!

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Heat Treating

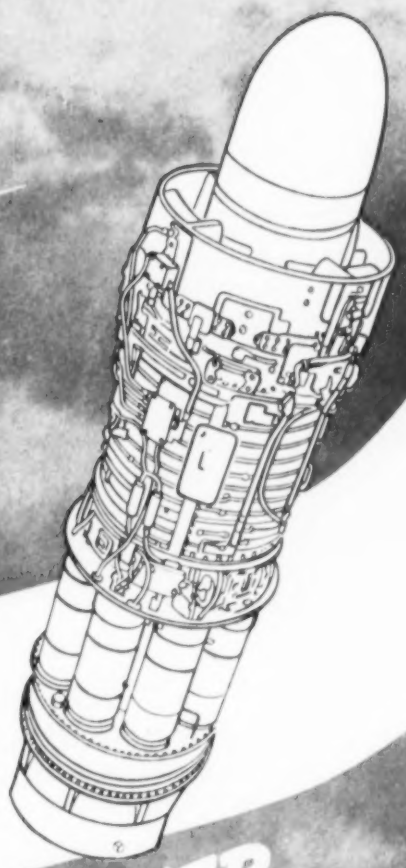
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The parts that go to make up a jet engine call for heat treating techniques as new as they are varied. Drever's long experience, through its own commercial heat treating division, has provided welcome solutions to many new problems of furnace design encountered in this field. Drever builds heat-treating furnaces of many types, with special adaptability to treating Stainless Steels of the 300 and 400 series, as well as Nimonic, etc.

Drever furnace application engineers will look forward to the opportunity of discussing your problem with you.





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CONTINUOUS ANNEALING OF WELDMENTS, STAMPINGS, ETC.
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Also installations for caustic descaling including quench and acid dip tanks

DREVER CO.

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8

Personals

Antoni Tabak, recently inducted into the Army, has been assigned to Frankford Arsenal where he is working on titanium casting problems.

Franklin D. Wicks, a recent graduate of Colorado School of Mines, is now with the American Smelting & Refining Co., Perth Amboy, N. J., as development engineer.

Irving J. Donahue, Jr., is now plant manager at Carlstrom Pressed Metal Co., Westboro, Mass.

John E. King, assistant to the sales manager, Worcester Pressed Steel Co., Worcester, Mass., has been installed as chairman of the New England district of the Pressed Metal Institute. As district chairman, Mr. King plans New England meetings and conferences and acts as liaison between the district and national offices of the Institute.

S. A. Crabtree is now assistant general manager of sales of Republic Steel Corp., Cleveland. He was formerly district sales manager of the Chicago district for the corporation.

C. H. Wyman, superintendent of melting at Burnside Steel Co., Chicago, was elected president of the Electric Metal Makers Guild, Inc., at the annual meeting in Albany, N. Y., in June. **W. W. Hart**, superintendent of melting at Ford Motor Co., Dearborn, Mich., will hold office as vice-president of the Guild during the coming year, and **C. B. Williams**, superintendent of melting at Massillon Steel Casting Co., Massillon, Ohio, was elected secretary-treasurer.

Hans J. Heine has resigned as chief metallurgist with Rockwell Mfg. Co., Barberton, Ohio, to become acting technical director of the American Foundrymen's Society in Chicago. Mr. Heine will coordinate all technical activities and research projects of the Society, working with the headquarters staff as well as the various appointed committees.

Raymond Fostini has resigned his position as metallurgist at Frankford Arsenal, Philadelphia, to accept a position as research associate at Columbia University while studying for a doctorate in metallurgy.

Maj. Bennett E. Robertson, USAF, is now chief scientist in the Nucleonics Branch, Materiel Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio.

S. J. Sindeband has been elected president of the Mercast Corp., New York. He is also president of Alloy Precision Castings Co., Cleveland.

John M. Parks is now manager of the metallurgical process division of Air Reduction Research Laboratories, Murray Hill, N. J., and is responsible for the welding, process metallurgy and physical metallurgical sections. Mr. Parks was formerly supervisor of welding research, Armour Research Foundation, Chicago.

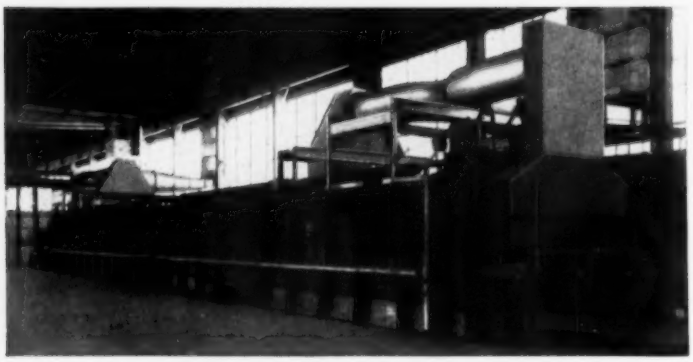
Nathan A. Tiner has been appointed research engineer for the North American Aviation, Inc., at Downey, Calif. Prior to this he was development metallurgist for the Columbia-Geneva Steel Div. of the U. S. Steel Corp., Pittsburg, Calif.

Joseph S. Turner, formerly research metallurgist with the Steel and Tube Div. of the Timken Roller Bearing Co., Canton, Ohio, is now materials engineer with the Coleman Co., Wichita, Kan.

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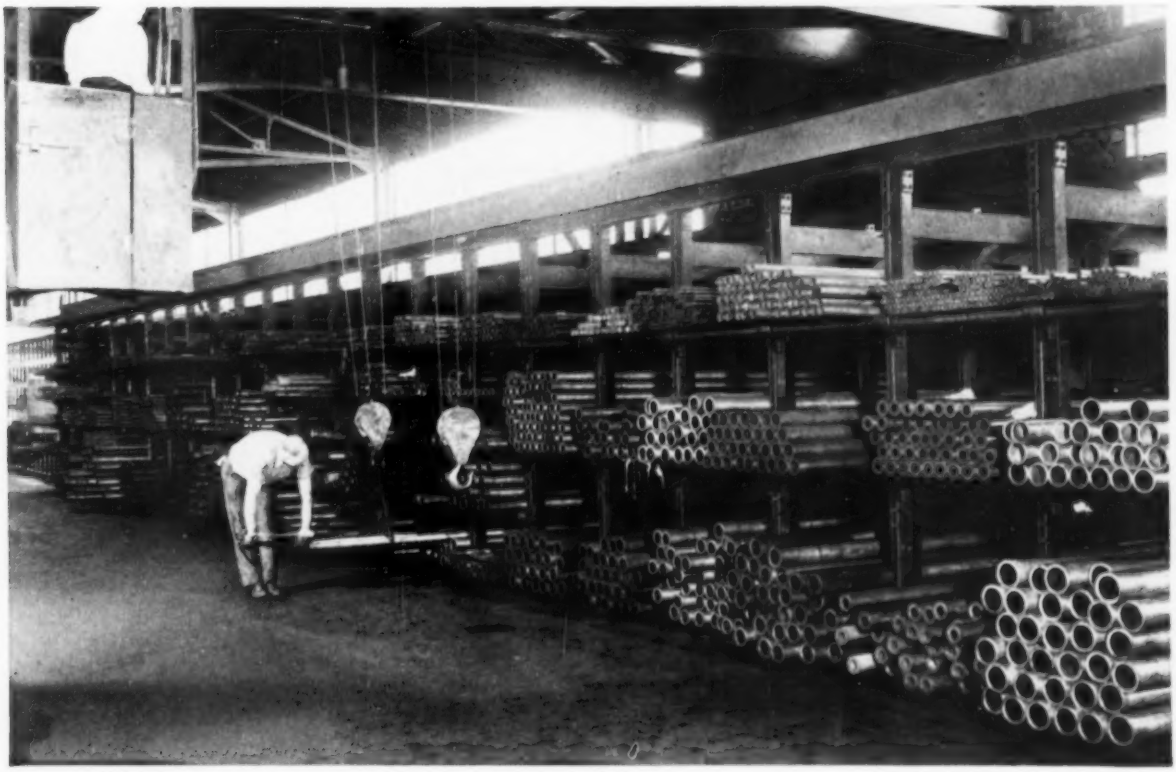
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Patent Disclosures
(Minimum Requirements)

By Carl H. Gerlach

Whenever a patent is applied for on an invention which is new, useful, and workable (the three requirements), two things can eventually happen: A patent may be granted without a hitch or, on the other hand, another inventor may have applied for a patent on the same thing. If the latter, the Patent Office institutes an "interference" which is a legal procedure to determine which of the applicants is the first inventor. The first inventor (the one who gets the patent) is the one who has the earliest date of "reduction to practice".

Reduction-to-practice papers may be written like a patent and must include:

1. An indisputable date and place.
2. A clearly identified inventor.
3. A clearly understandable presentation of a workable embodiment of the invention, and how it works.
4. A convincing statement of how and why and in what ways it is *(a)* new, *(b)* useful, and *(c)* what its advantages are. Point *a* requires adequate signatures of trusted witnesses (a minimum of two) who can later testify as to what, when, and how it works. Otherwise it requires a notary who *understands* fully what it is and notarizes it.

The date of reduction to practice obviously is of no value in an undisputed patent application; but in disputed (interference) patent cases nothing is more important. Therefore, such a disclosure should be written with the thought in mind that your opponent in an interference proceeding before the Patent Office will take advantage of its every weakness.

It is recommended that a check list be used against a disclosure on the following points:

1. Is the general purpose and object clear?
2. Old former methods covered?
3. Disadvantages of old methods indicated?
4. Is description of invention sufficiently clear to permit others to build it?
5. Have any details of operation been omitted?

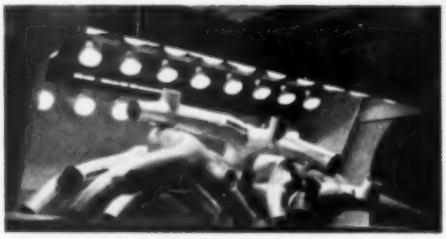
(Continued on p. 124)

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Photo courtesy Rohr Aircraft Corporation



Shown are aircraft manifold weldments of stainless steel. Dy-Chek has clearly indicated the presence of dangerous surface flaws in these semi-finished components. *Photo courtesy Rohr Aircraft Corporation, Chula Vista, California.*

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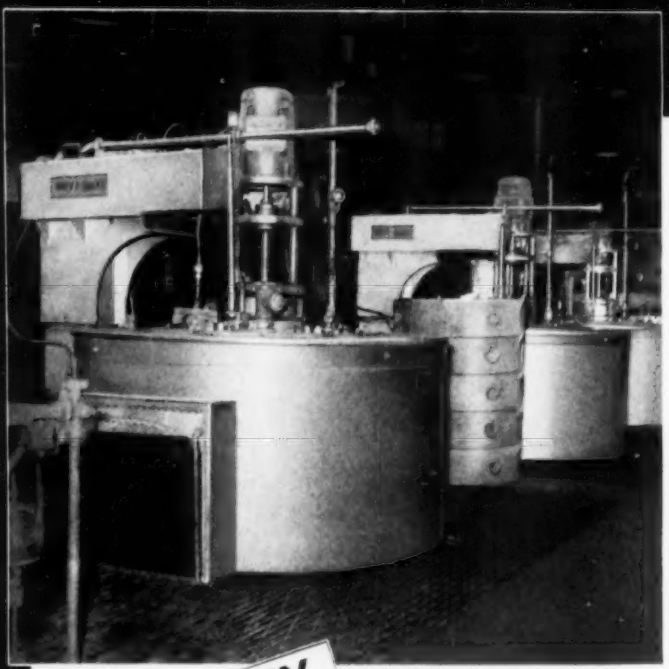
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Patent Disclosures

(Continued from p. 122)

6. Are advantages of the invention fully covered?

7. Have you described alternate methods of construction or improvements on the inventions which could circumvent a patent?

8. If a joint invention, what did each contribute? (Incorrect decisions on joint inventorship will result in an invalid patent.)

9. Did you make completely clear what was new?

10. Do your witnesses really understand it? If not, they are worse than none at all!

11. If you, the inventor, were to die a few days after disclosure is written, is there someone who could supply missing information as to tests, experiments, location of models, persons to whom ideas were disclosed and dates, numbers and dates of sketches, thoughts or ideas you have had about the invention.

12. Date and circumstances, also documentation, of conception of the idea. Also, date when inventor began to exercise diligence in perfecting invention.

A patent is a contract between an inventor and the government. In any contract, both parties must give a consideration, such as a sum of money or something useful to the other in order that the contract be binding. In a patent, the government gives the inventor the right to exclude others from making or using his invention for 17 years, thus giving a consideration. The inventor gives to the public, after 17 years, sufficient information in the patent to build and use his invention to the public's own benefit, thus giving a consideration.

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Pravda Reports on Russia's Progress in Ferrous Metallurgy*

According to the directives of the Nineteenth Congress of the Communist Party, the increase of pig iron, steel ingots, and rolled steel production in the fifth 5-year plan period should exceed that achieved in the course of the three successive prewar (1928 to 1941) plans. The over-all plan for greater advancement of Soviet ferrous metallurgy during the current 5-year plan demands further improvements in organization and technology, so as to increase the output per man-hour and to make fuller use of productive capacity.

The author then enumerates some of the more outstanding achievements of the Russian iron and steel industry between 1940 and 1951. In this period, the utilization of blast furnaces increased by 35%, that of openhearth furnaces by 42%. In recent years, certain metallurgical plants exceeded considerably their production quotas. In 1951, 95% of all pig iron was obtained from furnaces equipped with automatic control of blast preheating, and 87% of steel from openhearth furnaces equipped with automatic temperature controls. Plant mechanization and application of various automatic controls enabled the productivity per man-hour to be increased by 61%. (In 1952, the U.S.S.R. produced about 25 million tons of pig iron, 35 million of steel ingots, and 27 million of rolled steel.†)

After this introduction, various problems are mentioned which are still in need of technical solution or improvement, and Bardin deals first with the question of ore preparation and processing. He points out that, although the current 5-year plan (1951-55) provides a 32% increase in the production facilities for pig iron, it also aims to triple the iron ore processing capacity. Soviet metallurgy is due to embark on a vast program of utilizing low-grade iron ore, and in this connection it is nec-

(Continued on p. 126)

*Digest of "The Important Tasks of Technical Progress in Ferrous Metallurgy", by I. P. Bardin, *Pravda*, May 27, 1953.

†Reviewer's comment.

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Russia's Progress in Ferrous Metallurgy

(Continued from p. 125)

essary to improve considerably the ore concentrating techniques. The traditional ones now in use do not yield high-quality concentrates, nor do they guarantee a sufficiently thorough extraction of iron from the raw ore. For this reason, the problems of enrichment of the Crimean ores, as well as of certain others mined in the eastern regions, have not been solved satisfactorily as yet.*

Reduction of ash and sulphur content in coking coals is very important for the metallurgical industry of the South, of Kazakhstan, Eastern Siberia, and the Far East. In this connection, the possible use of lignite for ironmaking and the installation of electric blast furnaces in areas having cheap hydro-electric power are said to deserve serious consideration.

An important role in the improvement of technical and economic factors of ironmaking was played by the increase of blast furnace sizes. Over half of the total pig iron production comes from furnaces having a useful volume of 35,000 cu.ft. or more. A further increase is being contemplated. It is also advisable to employ more generally a blast with controlled constant moisture content and higher gas pressures in the furnace.

There was a considerable improvement in the performance of open-hearth furnaces, due mainly to improved quality of refractories and widespread application of automatic controls. Yet it is timely to consider the construction of 450 to 500-ton units instead of 350-ton furnaces, these being the largest in use at present. This would eliminate the lagging of steelmaking production behind the rolling capacity.

The use of waste-heat boilers is strongly advocated in order to lower the consumption of fuel for smelting operations. It is emphasized that much too little was done in this direction so far, and actual use of such boilers is quite limited. From 20 to 25% of the heat produced during the smelting operation can be reclaimed by such measures.

In view of the abundance of raw materials for making cheap bessemer

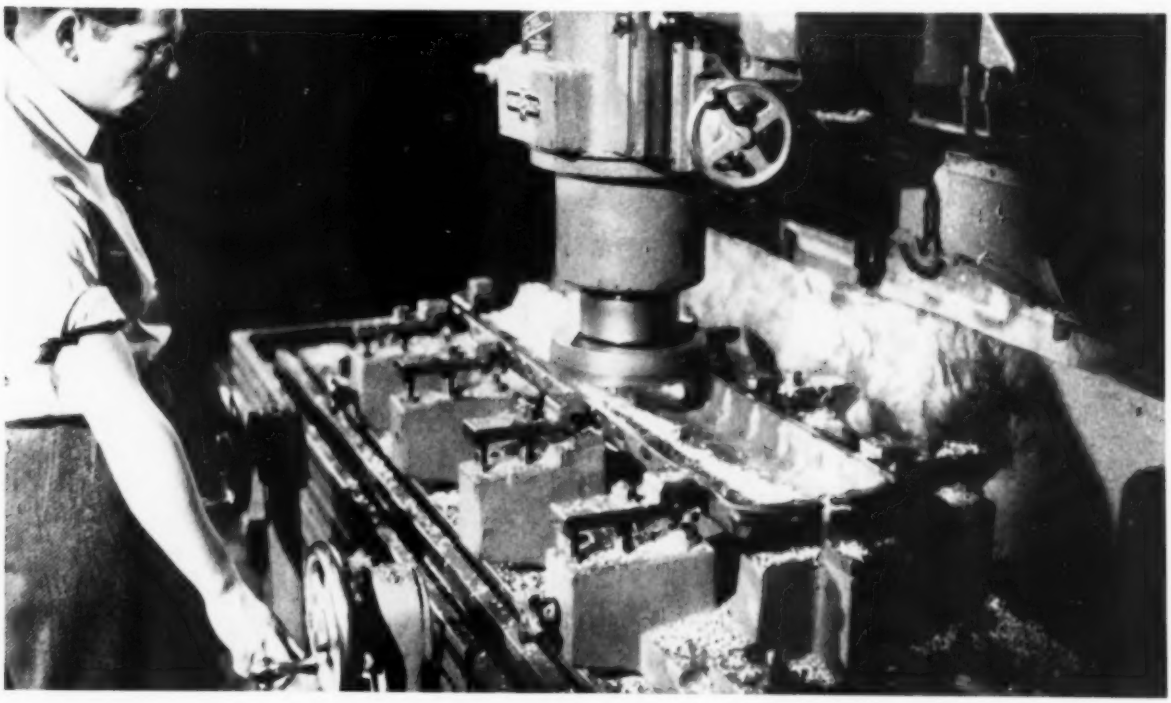
(Continued on p. 128)

*See reviewer's comment at end of article.

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Russia's Progress in Ferrous Metallurgy

(Continued from p. 126)

and Thomas steel, it is imperative to use all means to improve quality of the latter. It is well known that the nitrogen content of converter steel can be reduced very substantially by blowing the metal with blast containing very little or no nitrogen, the product being equal in quality with openhearth steel.

Regarding rolling mill production, the metallurgists must attempt to reduce the amount of scrap and improve the ratio of ingot weight to weight of usable rolled products obtained from it. For this, sound ingots are essential, but it is also extremely important to solve satisfactorily the problem of continuous casting of steel (see reviewer's comment at end of article). So far as equipment is concerned, the author stresses the need for designing and introducing specialized equipment such as multiroll mills for rolling very thin strip, mills for broad-flange beams, and for thick-walled tubing.

Finally, he refers to the role of scientific inquiry into metallurgical problems, and strongly emphasizes the importance of cooperation and close liaison between scientists and production metallurgists. He suggests that only in that way will positive results of laboratory work find their way to the plants and to full-scale production practices. Collaboration of this kind cannot but further technical progress.

REVIEWER'S COMMENT: I. P. Bardin is director of the Institute of Metallurgy of the U.S.S.R. Academy of Sciences and was for a number of years (and perhaps still is) Deputy Minister of Metallurgical Industries. It is appropriate to recall that in a leading article appearing in the November 1952 issue of the *Bulletin* of the U.S.S.R. Academy of Sciences (*Izvestya Akademii Nauk, SSSR*), a prominent member of this Academy, A. A. Blagonravov, wrote as follows:

"The scientific activities of Academician I. P. Bardin are directed toward the introduction of new techniques and improvement of technology in the metallurgical industries. . . . With his name is connected the *solution* of the problem of *utilization of the Crimean iron ores*, making of electrolytic manganese, *continuous casting of steel*, . . . *utilization of low-grade iron ores*." Thus he ascribes to Bardin directly or by implication the solution of problems which Bardin himself declares unsolved half a year later.

N. H. POLAKOWSKI

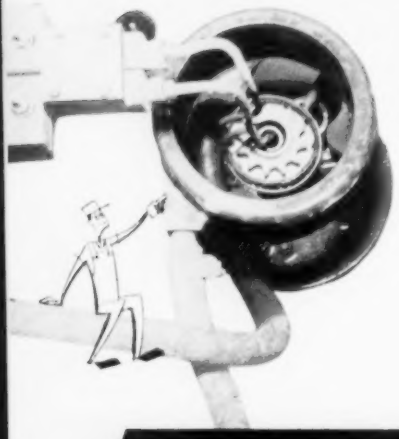


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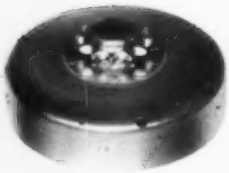
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Plating Waste Treatment*

CHROMIUM, nickel and copper acid-type plating solutions may be reclaimed from the rinse tank by evaporation in glass-lined equipment or other suitable evaporators and the concentrated solution returned to the plating system. Atmospheric or vacuum systems may be used. Vacuum systems are better where organic materials are present, since they reduce the possibility of decomposition by permitting evaporation to take place at low temperatures.

The water condensed from the steam is then used in the first rinse following the plating tank to eliminate buildup of natural water salts.

So far, this process has been confined to acid solutions recovered in still dip tanks immediately following the plating solution. Supplemental chemical treatment may be necessary to maintain the solutions in balance. Initial cost of equipment is high, and the quantity of chemical to be recovered, plus the expected cost of operation of a treatment system if recovery were not practiced, would have to justify use of the system.

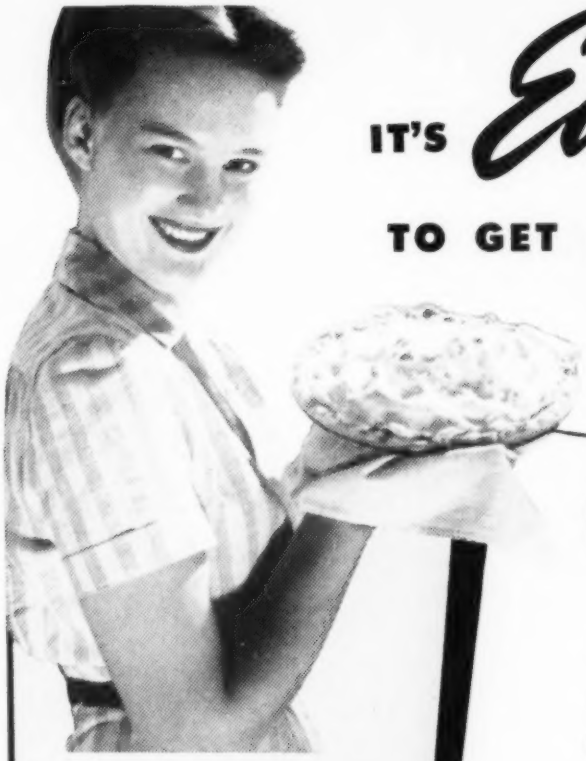
This process does not completely eliminate toxic materials from the plant effluent since it is only applied to the first rinse following the plating system. Subsequent rinses will still discharge relatively small quantities of the polluting agent. Natural water salts or other contaminating materials may build up in solutions and limit the number of cycles of this process. Ion exchange resins (which are described subsequently) can be used to remove contaminating metals before evaporation.

Data on an 800-gal. batch operation in one plant indicate that a solution containing from 1 to 4 oz. per gal. chromic acid is readily concentrated to 10 to 35 oz. per gal. final product, this being returned to the plating bath. Equipment is rated at a maximum of 450 lb. of steam per hr. at 75 psi.; it is operated at 27-in. vacuum for 8 hr.

Another plant concentrates the

(Continued on p. 132)

*Digest of chapters "Metal Recovery by Ion Exchange" and "Solution Concentration and Recovery by Evaporation" of the book "Methods for Treating Metal-Finishing Wastes", published by the Ohio River Valley Waters Sanitation Commission, 414 Walnut St., Cincinnati; price $2.00.



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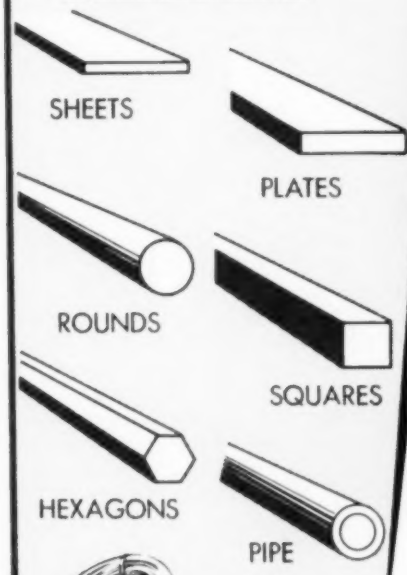
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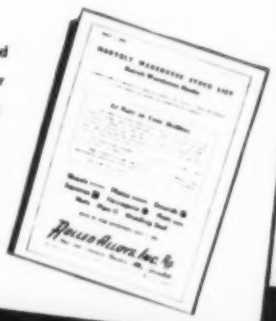
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Plating Waste Treatment

(Continued from p. 130)

rinse water following the chromium plating tank by a continuous evaporation process. The solution is circulated through a pyrex glass heat exchanger into the top of a tower through which air is forced countercurrent to the flow of the solution. Temperature of the solution entering the concentrator tower is 178° F. It requires 682 lb. of steam per hr. to evaporate the water from a solution having a concentration of 37 oz. per gal. at a rate of 1 gal. per min. This process is said to offer an excellent promise where chemical quantities involved are relatively large and would justify recovery.

Metal Recovery – Best application of ion exchange is the treatment of rinse waters following plating operations. Rinse water is passed through beds of cationic and anionic resins which are selected for the particular application. The de-ionized water is recycled through the rinse tank. The exchanger beds are treated periodically with a solution designed to regenerate the resins, and therefore the regenerating solution will contain the concentrated salts originally in the rinse water. Further treatment may be required to reclaim the metal salts in a suitable form for re-use.

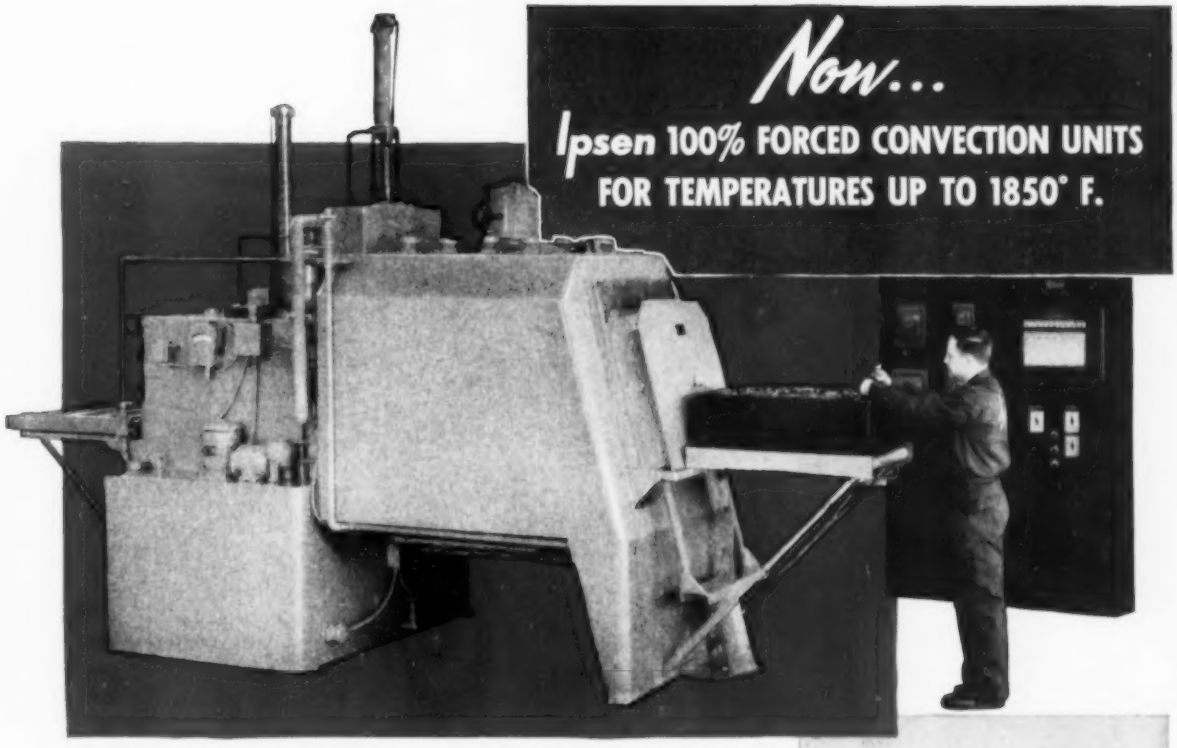
The method may be applied to the removal of contaminating metals from chromic acid solutions on a continuous basis, returning chromic acid solution to the process tank. Iron, aluminum and trivalent chromium can be removed from chromic acid solutions because they are cationic contaminants, whereas the chromic acid is anionic and therefore would not be extracted. With nickel and copper plating solutions, both the contaminating metals and the metal to be plated are cationic, and therefore all will be extracted.

In the evaporative process for recovery of chromic acid, the parts being plated are immersed in a still dip immediately following the plating bath. When this dip has arrived at a predetermined concentration, the solution is transferred to an evaporator and the concentration increased to a point closer to that in the plating solution. This concentrate is then transferred to the plating solution. Any metals introduced to the still dip as a result of solution

(Continued on p. 134)

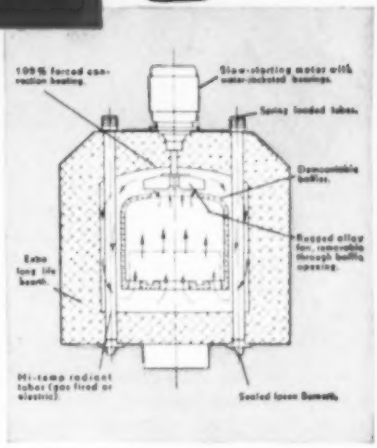
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Plating Waste Treatment

(Continued from p. 132)

of metal from parts during the plating process are included in this concentrate. To eliminate these, the still-dip solution can be passed through a cation resin exchanger before transfer to the evaporator.

Some means of treatment for the regenerated solution must be used, since this is simply a concentration method. The chemicals used for regenerating the resin beds may also require special treatment before disposal, and the rinse water following regeneration may need treatment.

J. PARINA, JR.

New Microscopy Technique*

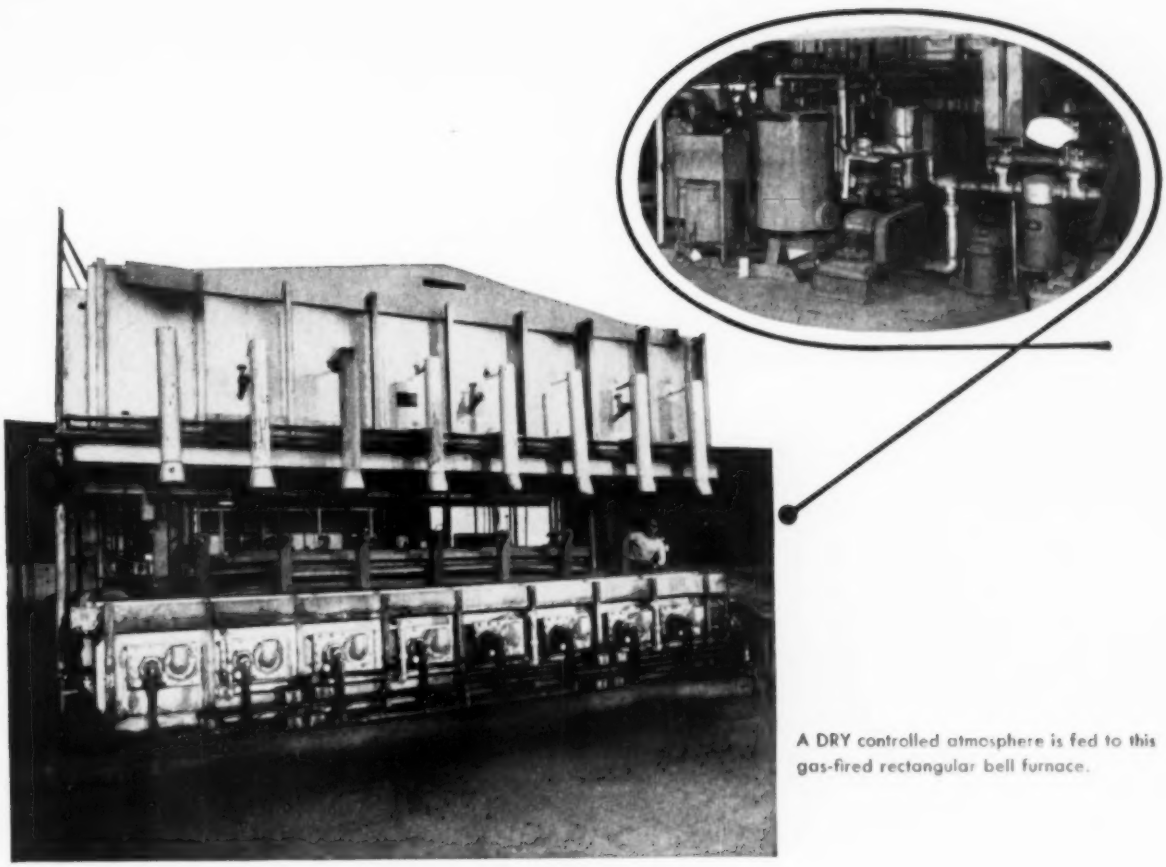
OBLIQUE ILLUMINATION, dark-field illumination, polarized light, interferometry, etching methods (such as staining), all have been used to increase the contrast of the microscope image, and now a new method, "phase contrast", has been added.

The principle of the phase-contrast method is that differences in the optical path can be made visible as differences in intensity. The light waves from one elevation (or constituent) of the specimen show small phase displacements relative to the light waves from a different elevation. These phase displacements are seen as differences in intensity when a device for accentuating the differences in phase is introduced into the optical path. Hence the name, phase contrast. This term does not refer to differences in phases in the physicochemical sense, although it can be used to differentiate such phases.

By Abbe's theory of image formation in the microscope, the direct image of the annular aperture (diffraction maximum of zero order) and diffraction patterns from the details of the object form at the back focal plane of the objective. The diffraction maxima from the 1*st* to *nth* order interfere with the zero order maximum and give an image, at the image plane of the objective, which corresponds with the object in amplitude and phase. Due to the similarity of the image to the object,

(Continued on p. 136)

*Digest of "The Incident-Light Phase-Contrast Microscope and Its Use in Metallography", by Fritz Gabler and Roland Mitsche, *Stahl und Eisen*, Vol. 23, 1952, p. 145-150.



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New Microscopy Technique

(Continued from p. 134)

the image will exhibit contrast proportional to the differences in the absorption of its details. On the other hand, an object exhibiting only differences in optical path that are invisible to the eye will present no contrasts in its image, despite all the diffraction phenomena caused by its irregularities.

In the transmitted light microscope, small differences in optical path are readily converted to intensity differences by placing at the back focal plane of the objective a phase-contrast plate. If the diffraction pattern is influenced by inserting at the back focal plane of the objective a transparent dielectric foil of suitable thickness covering the pattern, the light vector representing the effect of the details of the object (in other words, the light vector which originates the diffraction pattern) is rotated through 90° to increase (or decrease) the vector defining the light wave from any random detail, and the detail of greater optical path appears darker (or lighter) than adjacent detail.

For negative phase contrast, when the detail of greater optical path appears brighter, the zero order diffraction maxima are covered by the foil, and the phase plate is annular in shape; for positive phase contrast, 1*st* to *nth* order covered, the foil covers the complementary area.

Contrast can be enhanced still further in positive phase contrast by covering the zero order diffraction maxima with an absorption ring, a thin and partly transparent coating of metal.

For the transmitted light microscope the phase plate is incorporated into the objective, making a "phase objective"; but, since the phase annulus then lies in the illuminating path of rays, reflection difficulties were experienced in applying the method to incident-light microscopy.

For this and other reasons the adaptation to the metallurgical microscope was simply to add a number of new parts. These new parts were an annular diaphragm aperture lying in the front focal plane of the condenser; "extra optical components", consisting of two lenses introduced between the illuminator

(Continued on p. 138)

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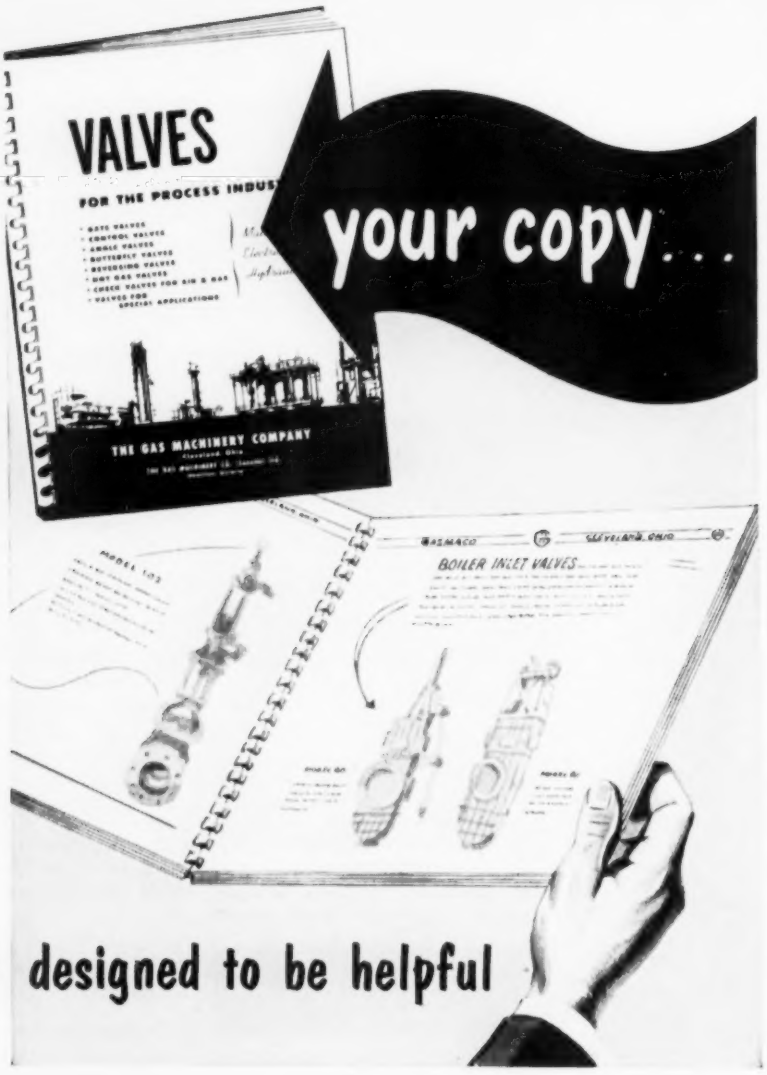
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New Microscopy Technique

(Continued from p. 136)

and the image; and the phase plate, placed where the "extra optical components" form one of the images of the annular diaphragm aperture. The position of the phase plate is checked with an auxiliary microscope so that the image of the annular diaphragm aperture coincides with the image of the phase plate absorption ring. The authors promise a later paper which will clarify details of the extra optical components.

Several metallographic specimens were studied and photographs were made to compare the bright-field and phase-contrast methods of illumination. Positive phase contrast was always used, which means that the constituents that were higher were brighter. "Higher" refers to comparatively small differences in level, of the order of 10 to 50 A. If the differences are too great, a reversal of the phase-contrast image occurs. By comparison, normal interferometer methods do not enable values lower than 200 to 300 A to be detected.

Comparisons were made for an unetched complex bronze, and an unetched ledeburitic toolsteel, as cast, both at 500 ×. Phase contrast reveals several different constituents of the bronze invisible without phase contrast. The toolsteel has undergone a relief polish, which becomes more evident with phase contrast.

Two micrographs at 500 × of pearlite in etched gray cast iron show structure differentiation better with phase contrast than without. Some of the details seem to be sharpened by phase contrast, some suffer a little – perhaps a matter of difference in elevation and focus.

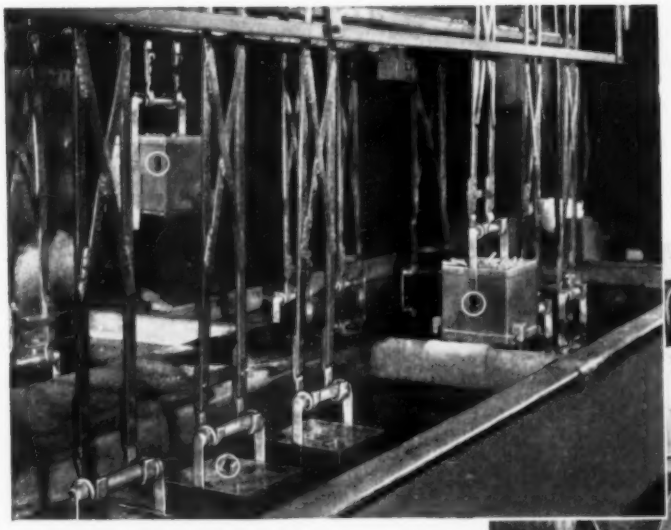
In the micrograph of an unetched hypereutectic copper-oxygen alloy, the cuprous oxide particles under direct illumination are outlined by a sharp black line as a result of interference of light rays reflected by *(a)* the copper matrix and *(b)* the surface of the cuprous oxide particles standing out slightly in relief. With phase contrast the black outline becomes a bright white line, since the difference in paths of the two reflected beams is almost half a wave length, or 1500 A as determined by interferometric measurements.

(Continued on p. 140)

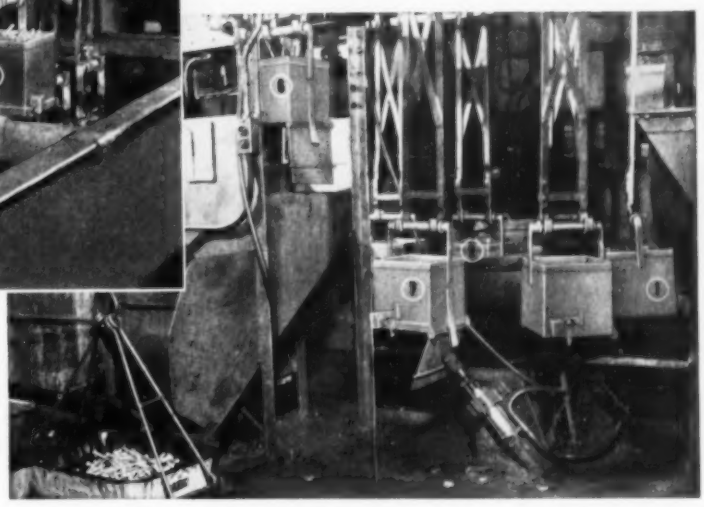
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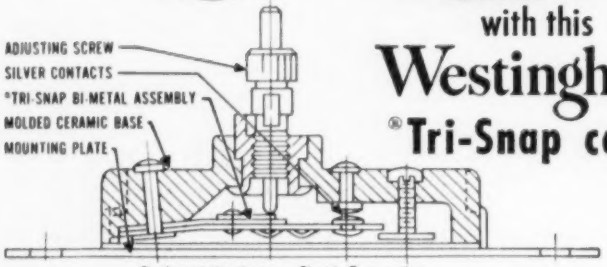
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New Microscopy Technique

(Continued from p. 138)

In a mixed structure of sorbite, troostite, bainite, and martensite in a quenched steel, the phase-contrast photograph reveals the martensitic structure more clearly but does nothing for the other constituents.

Photographs of sorbitic structure (1000 ×, etched) in cold drawn wire show what seems to be greater resolution in the photograph with phase contrast, although, of course, no increase in resolution is theoretically possible.

As the resolution limit of the microscope is approached, the depth of focus decreases so that extremely light metallographic etches must be used at high magnifications. The phase-contrast method can, therefore, give an apparently greater resolution by increasing the elevation contrast in a necessarily shallow etch. The addition of the phase-contrast method to the metallographic microscope is not difficult since no special objectives are needed and the phase-contrast plate may be readily removed from the optical train to make comparisons between the bright-field and phase-contrast methods.

ELIZABETH HARTNER

High-Temperature Strength of Aluminum-Magnesium Alloys*

IN DIAGRAMS of composition versus high-temperature strength, an important question is the influence of temperature on the equilibrium of the alloys, especially at the lower temperatures of the range. Thus, what is the relation between composition, chemical structure of the alloys, and the character of the change of high-temperature strength with temperature? In a pure metal or in an alloy of fixed composition, the creep rate at a given stress increases with increasing temperature. However, the corresponding behavior of an *alloy system* is much more complicated. There is as yet little experimental material to answer this question. *(Continued on p. 142)*

*Digest of "Effect of Temperature on the High-Temperature Strength of Alloys in the Aluminum-Magnesium System", by I. I. Kornilov and L. I. Pryakhina, *Doklady Akademii Nauk SSSR*, Vol. 87, 1952, p. 971-974.



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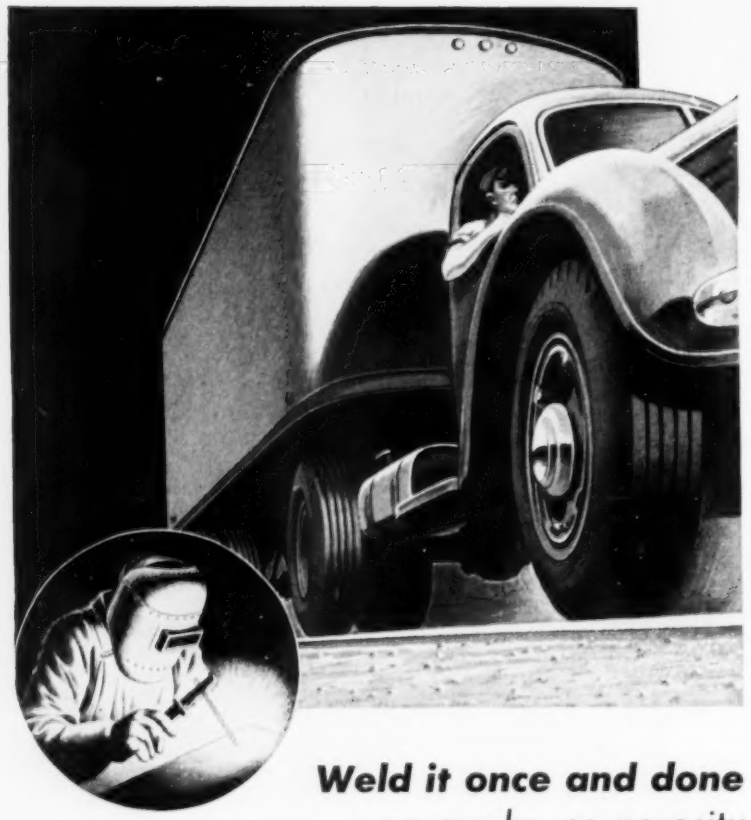
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WELD WITH ARCOS
LOW HYDROGEN ELECTRODES

Strength of Aluminum-Magnesium Alloys

(Continued from p. 140)

The authors state they have established in their previous work that in an alloy system exhibiting limited terminal solubility, the maximum high-temperature strength – within a certain temperature interval – occurs in the region of maximum saturation of the solid solution. The temperature interval for which this rule holds is different for different alloy systems and depends on the melting temperatures of the alloys and component metals, and on the simplicity or complexity of the constitutions of the solid solutions. With increasing temperature the maximum in strength at the limit of solid solubility gradually fades away; acceleration of diffusion at high temperatures leads to the solution of the excess phase for increasing solubility with temperature, or to the formation of excess phases for supersaturated solid solutions. Under these conditions, Bochvar's solution-precipitation mechanism of softening comes into play. However, this leads to the necessity of eliminating this mechanism, not on account of heterogenization of an alloy, but because of stabilization of the constitutions of the solid solutions.

These fundamental factors determining the high-temperature strength of alloys must cause a change in the character of the diagram of composition versus high-temperature strength for limited solid solutions as the temperature increases. Therefore, it is not sufficient to consider only the external, geometric features of the constitution diagram. The authors showed in 1951 that for the limited solid solutions in the aluminum-magnesium system, the character of the change with temperature of the diagram of composition versus high-temperature strength was quite unusual.

Creep data were obtained using a centrifugal testing machine, and the data were reported as the time required for a certain degree of bending to occur at constant temperature and initial stress. At 200° C. (390° F.) and a stress of 2330 psi., and also at 300° C. (570° F.) and a stress of 1140 psi., the maximum time was observed for the composition corre-

Strength of Aluminum-Magnesium Alloys

sponding to maximum solubility of the solid solution, 3 and 6% magnesium respectively. At 350° C. (660° F.) and a stress of 480 psi., the maximum time was at 6% magnesium, although the maximum solubility is more than 8% at this temperature. At 400° C. (750° F.) and a stress of 240 psi., the maximum time occurred for pure aluminum.

This change in behavior with increasing temperature is understandable when it is recalled that at a given temperature a solid-solution alloy is closer to the solidus line the richer it is in magnesium. Thus, a similar effect has been observed in the nickel-chromium system. At 800° C. (1470° F.) the maximum high-temperature strength is at 36% chromium, which is the limit of solid solubility, while at 1100° C. (2010° F.) the maximum is at 30% chromium and the solubility limit is 40%.

The data on the aluminum-magnesium system show that the effect of temperature is so pronounced that the compositions of lowest and of highest strength are interchanged with change in temperature.

A. G. Guy

Machinability of Leaded Steels*

THE PRESENCE of soft sulphide inclusions in a steel materially enhances its machinability, while the presence of hard silica or alumina inclusions impairs machinability by increasing tool wear. For best machinability the sulphide inclusions in a free-machining steel should be small and uniformly distributed throughout the mass of the steel.

Lead inclusions have a greater effect in improving machinability than sulphide inclusions. Furthermore, the presence of up to 0.3% lead in a steel appears to have very little effect on mechanical properties, response to heat treatment and resistance to corrosion. A relatively high percentage of sulphur, on the other hand, tends to impair ductility,

(Continued on p. 144)

*Digest of "Metallurgical Aspects of Machinability of Steel", by W. I. Pumphrey, *Welder*, October-December 1952, p. 85.



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Machinability of Leaded Steels

(Continued from p. 143)

toughness, resistance to fatigue, and resistance to corrosion.

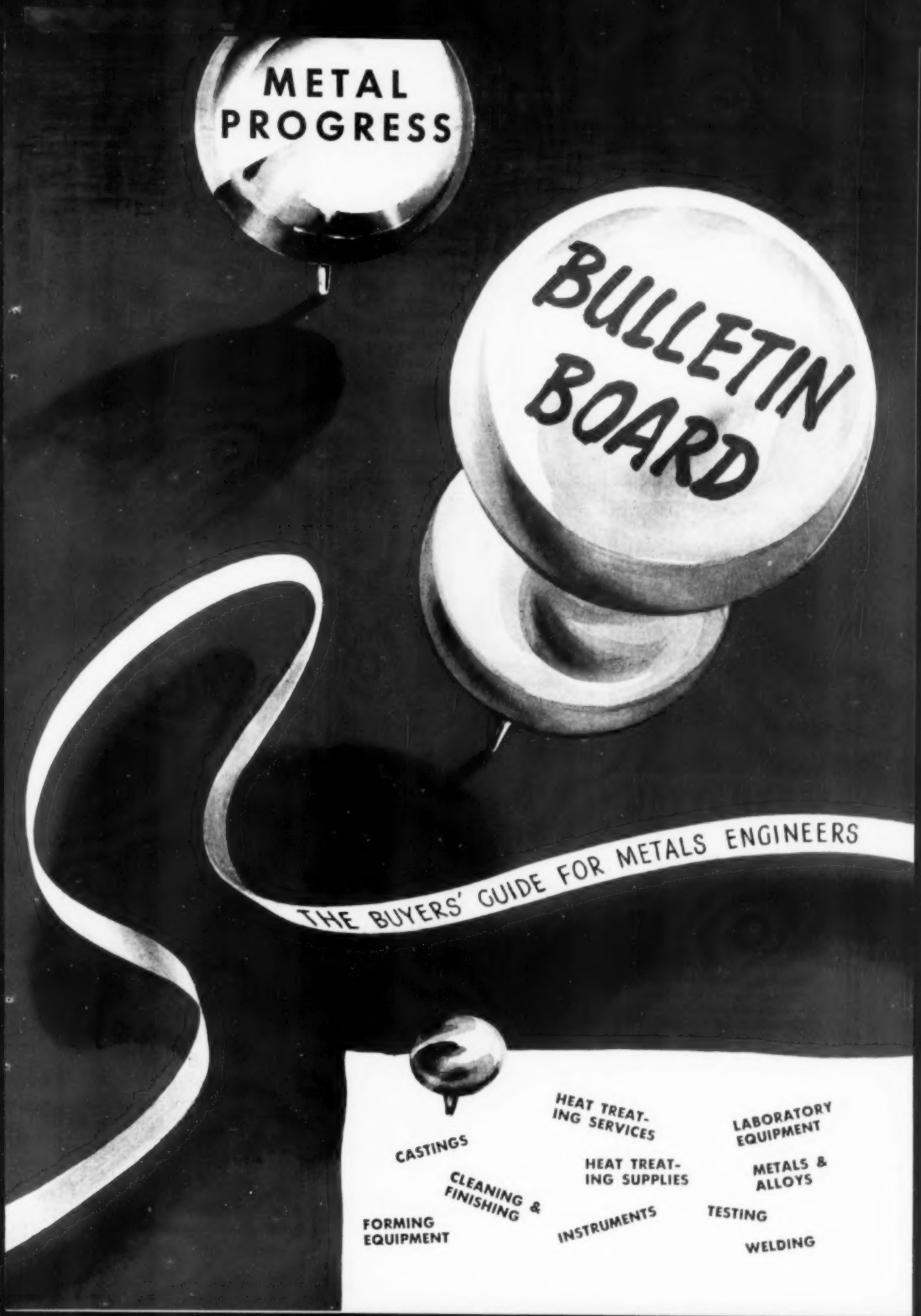
The precise function of lead in improving the machinability of steel is not known with any degree of certainty. A leaded steel gives shorter and more curly chips than a lead-free steel. It is generally considered that the greater chip curl and the reduction in the amount of heat generated during removal of the chip are due to the reduced friction between the chip and the tool caused by an ever-present and continually replenished thin film of lead on the machined surface of the stock. In support of this explanation Wragge has pointed out that cutting oils containing the usual small proportion of fatty acids tend to show an increasing accumulation of lead soaps after prolonged use, indicating that some reaction has occurred between the lead on the surface of the machined stock and the free fatty acids.

Schrader has shown that the coefficient of friction, under dry sliding conditions, is lower for a leaded low-carbon steel sliding over hardened high speed steel, than for the same steel when free from lead. These results indicate that at certain machining speeds there will be less frictional drag between chip and tool during the dry machining of leaded steels than of lead-free steels.

The improvement in machinability would thus seem to be due to the fact that the lead acts as a form of lubricant and so minimizes wear of the tool and reduces the heat generated during chip formation. Also the lead inclusions in the steel act as chip breakers and destroy the continuity of the ductile matrix.

To summarize, the machinability of a leaded steel is considerably superior to that of a high-sulphur free-cutting steel free from lead but of the same basic composition. Thus, for example, if the machinability index of a free-cutting steel having a high sulphur content but containing no lead is 12, then the machinability index of the same steel, in the same condition but containing 0.2% lead, is generally about 15. Up to 3% lead does not seem to increase the steel's corrodibility.

MARJORIE R. HYSLOP


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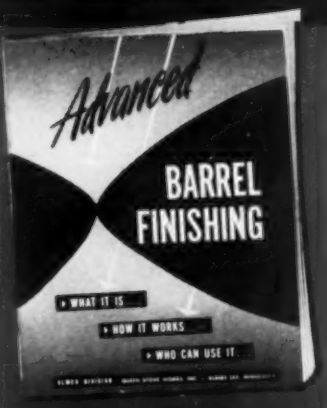
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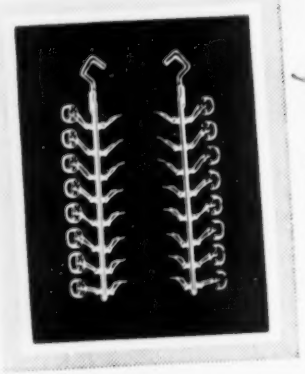
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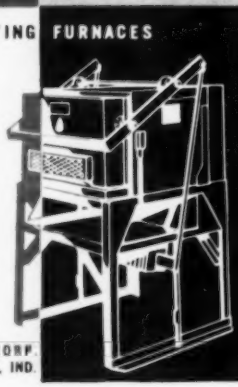
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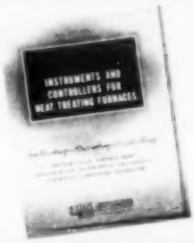
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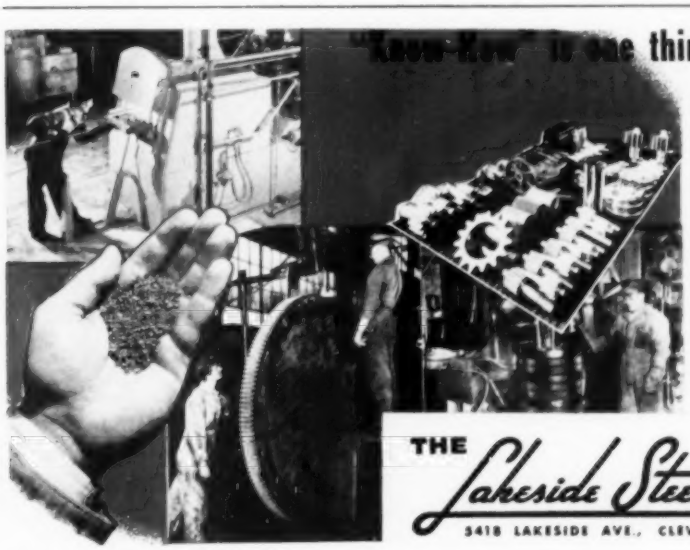
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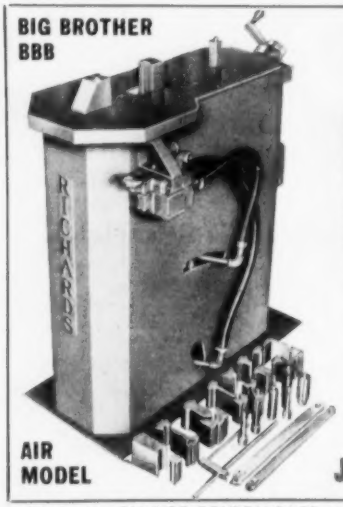
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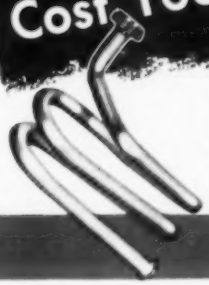
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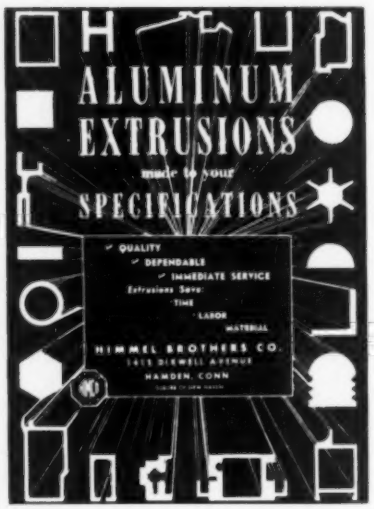
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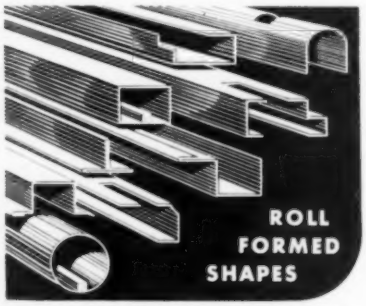
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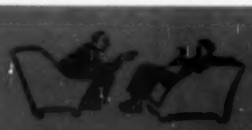
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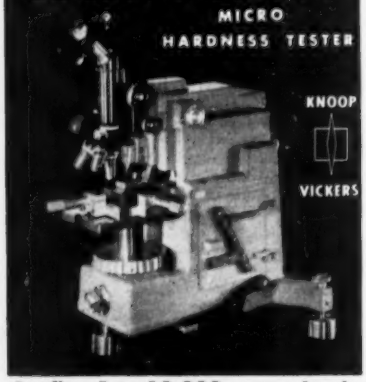
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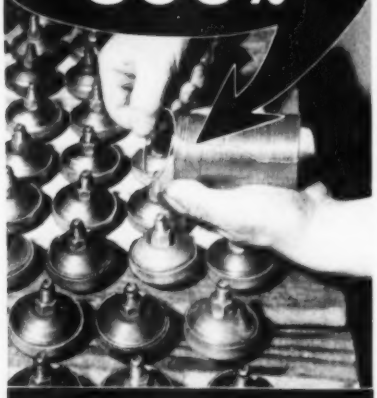
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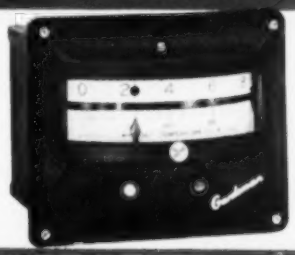
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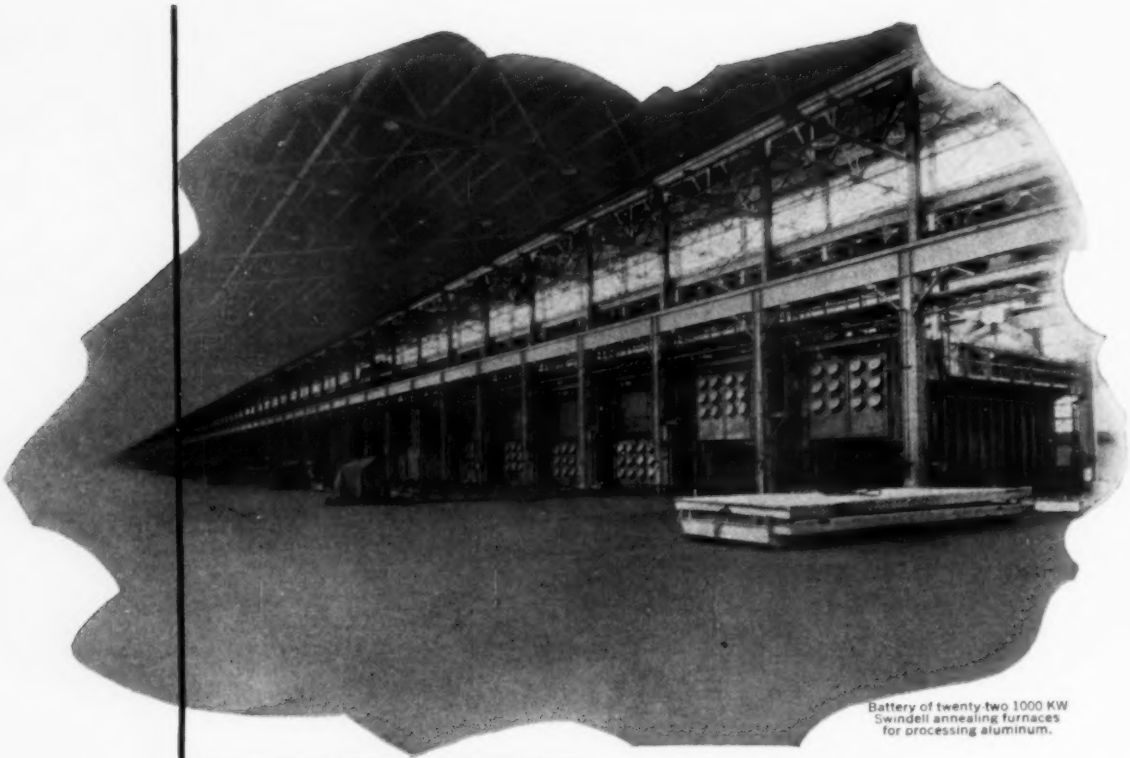


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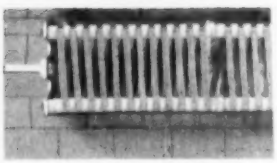
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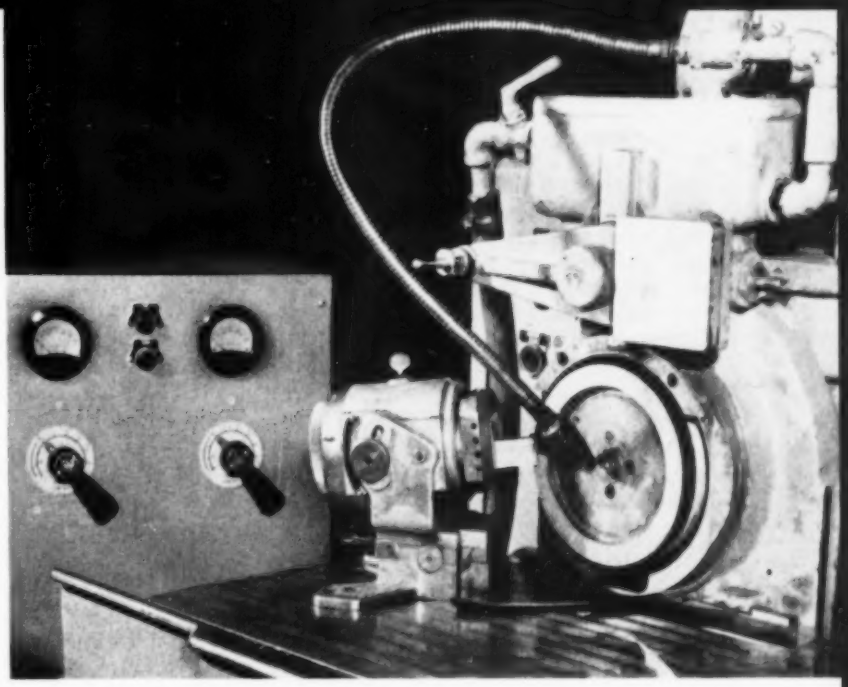


Fig. 1 – Bura-Way Tool Grinder Experimentally Converted for Electrolytically Assisted Diamond-Wheel Grinding. Splash and wheel guards removed

Grinding Carbide Tools With Electrolytic Assistance

DIAMOND-WHEEL grinding of cemented carbides assisted by electrolysis is a new technique that has been investigated by the research and development department of Norton Co. for more than a year. In this method diamond-wheel grinding is assisted by simultaneous electrolysis (electrochemical erosion or decomposition) of the cemented carbide. Preliminary studies show that it is a promising method for sharpening such single-point tools.

The initial experiments (see *Metal Progress* for May 1953, p. 198) were performed on a tool and cutter grinder equipped with a specially constructed constant-pressure device to simulate off-hand sharpening of single-point tools. The first tests indicated that metal-bonded diamond wheels, supplemented by electrolytic action using a proprietary rust inhibitor at a current density of about 250 amp. per sq.in., were able to cut at a commercially acceptable rate. Only a small fraction of the amount of diamond was consumed as for the same rate of cut in conventional grinding using a vitrified-bonded diamond wheel. On the other hand, there was evidence of some attack on adjacent edges of the carbide by electrochemical erosion.

At that time, it was felt that this newer method should not be recommended for the commercial sharpening of single-point carbide tools until certain additional information had been assembled. Needed were: *(a)* data on tool performance to ascertain whether the tools were adversely affected by the tendency for adjacent edges to be slightly eroded by electrolysis, *(b)* field experience to confirm laboratory conclusions as to rate of cut and diamond consumption, and *(c)* a thorough investigation of possible toxicity. Recent work has been directed toward an answer to these questions.

Since the laboratory setup used for the preliminary experiments simulated an off-hand operation but was not suitable for grinding actual single-point tools, a Norton No. 2 Bura-Way tool grinder which employs diamond wheels was converted for electrolytic assistance (Fig. 1, above).

This machine is a precision tool grinder which uses a tilting table, a universal tool-

Grinding Carbide Tools

(Starts on p. 161)

holder with protractor or a specially constructed template, to duplicate exact tool form. In converting it for electrolytic assistance, the cartridge-type wheel spindle was insulated from the spindle housing by nonconducting sleeves. Direct current was supplied by copper oxide rectifiers whose secondaries were connected in series to supply 0 to 24 volts, the maximum current rating being 230 amp. External resistances could be varied in nine steps from 0 to 2.61 ohms. Current was supplied to the insulated spindle by carbon brushes at the rear of the machine. In normal operation, the diamond wheel was negative and the carbide tool positive; means were provided for reversing polarity should electrochemical dressing of the diamond wheel be required.

The power supply was assembled from parts which could be obtained with minimum delay, and was purposely built with a high current-carrying capacity and with a large number of resistances to make it adaptable for experimentation. A suitable power supply for commercial use is being constructed.

Preliminary Performance Data — To obtain information on tool performance, eight comparative tests were made in four customer plants. In three tests a direct comparison was made between identical tools ground on this machine in the Norton plant using a vitrified-bonded diamond wheel in conventional grinding and a metal wheel for the electrolytically assisted operation. In five tests, tools formed with electrolytic assistance in the Norton plant were compared with identical tools diamond ground by the customer in his own plant using his own method.

In each of the three comparisons reported to date, there was no significant difference in tool performance. However, not more than three identical tools were compared in any of these reports. Although it was possible to determine that grinding time on the Bura-Way machine was about the same for the electrolytically assisted operation as for the conventional, the small number of tools ground did not permit measurement of wheel wear. The small number of tests might also raise some question as to the validity of the conclusions drawn from them.

FIELD EXPERIMENTS

Because of these limitations to the experiments on tools ground in our own plant, arrangements were made with a large automotive concern in Detroit to continue the experimental program. A large number of similar tools was available for regrinding, and high production operations would provide a better opportunity for evaluating tool performance.

Preliminary results are now available on two large carbide form tools of somewhat similar shape (Fig. 2). Rough grinding was done with vitrified-bonded silicon carbide wheels, and finish grinding with the Bura-Way machine on side and end relief faces only; the top face of the tool was not ground.

Metal-bonded wheels were used with electrolytic assistance, vitrified-bonded for conventional grinding.



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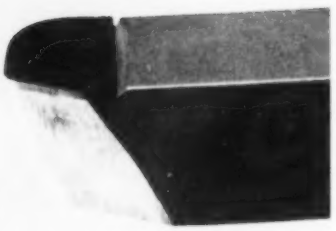


Fig. 2 – Carbide Form Tool Used in the Field Experiments

The electrolyte was a Socony-Vacuum rust inhibitor diluted with tap water and introduced to the center of the wheel at a rate of 3 to 4 gal. per min. The average carbide removal at the top front of the tool by diamond grinding was 0.016 to 0.020 in.

To test the tools they were used for rough turning of nickel steel on an automatic lathe; total depth of cut was about $\frac{1}{8}$ in. Criteria for judging tool life were ability to hold shape, and maintenance of satisfactory surface finish of the part. The tests are summarized in Table I.

From these data, we conclude that, compared with conventional diamond-wheel grinding, the use of electrolytic assistance resulted in one-quarter the diamond consumption, and approximately the same rate of cut. Considering the relatively small number of tools tested and the variation in performance from tool to tool, we believe there is no significant difference in average performance of tools ground in the three different ways. Slight evidence of edge erosion was found when the tools ground with electrolytic assistance were examined at 75 ×.

During the four months that the machine has been employed for electrolytic assistance, the electrolyte has not corroded any part of the machine or carbide tool shanks. Neither has there been any evidence of electrochemical attack on the worktable or any other part of the machine, although it has had no periodic flushing with water nor any other special attention.

To obtain comparative data from an off-hand operation, tests were conducted with the cooperation of a large carbide tool manufacturer who had converted an off-hand carbide grinder for electrolytic assistance. In this test 100 small tools of the same size and grade of carbide were finish-ground with a metal-bonded diamond wheel, electrolytically assisted. Current density varied considerably, but averaged about 250 amp. per sq.in.; the same electrolyte mentioned above was used. The results were compared with data obtained previously on 200 tools of the same size and type of carbide conventionally ground with a vitrified-bonded diamond wheel. The tests are summarized in Table II.

Taking into account the difference in diamond concentration, the electrolytically assisted operation required only slightly more than one-quarter the amount of diamond, but cut approximately 8% slower as compared with the vitrified-bonded wheel used conventionally.

The tools ground with electrolytic assistance showed the variable, dull

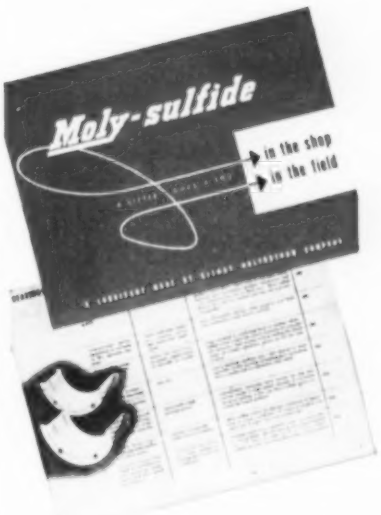
(Continued on p. 164)

Table I – Results of Tests in Automotive Plant

Test Data	Method of Grinding Tool		
	Conventional (Bura-Way)*	Electrolytic Assistance	Off-Hand Grinders
	Grinding Data		
Number of tools ground	36	82	
Linear wheel wear per tool	0.00017 in.	0.00004 in.	
Finish grinding time per tool	4 to 5 min.	4 to 5 min.	
Tool finish, micro-in. rms.			
Flat surfaces	5 to 9	4 to 6	
Profiles	14 to 16	10 to 14	
	Tool Performance Data		
Number of tools tested	26	33	41
Pieces per regrind, range	60 to 170	11 to 279	40 to 235
Arithmetic average	112	134	124

*Vitrified-bonded diamond wheel
†Metal-bonded diamond wheel

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Grinding Carbide Tools

(Continued from p. 162)

matte finish associated with this method of grinding, and there was some evidence of edge erosion at high magnification. Both of these factors, the manufacturer felt, would result in customer acceptance problems at the present time, although it is reasonable to conclude that these tools ground off-hand with electrolytic assistance probably would have performed satisfactorily, on the basis of the tool performance data reported above.

Since the electrolytically assisted method depends in part on electrochemical decomposition of the carbide, it would be logical to expect that toxic gases might be generated by decomposition of the electrolyte. The toxic gases most likely to be present would be ozone and nitrogen dioxide (a mixture of NO_2 and N_2O_4). Gas analyses were therefore made at the operator's breathing level using the laboratory setup; current density was 250 amp. per sq.in. A general exhaust was placed above the machine about a foot away from the grinding contact.

The analyses showed 11 to 16 parts per million of nitrogen dioxide, as against the permissible limit of 25 parts per million for an 8-hr. exposure per day. Ozone was 1.5 compared with a permissible limit of 1.0. A proper exhaust closer to the working area would undoubtedly reduce the ozone value to where it would be in the permissible range.

The ultimate goal of electrolytic operation is to eliminate the use of diamond entirely in the sharpening of single-point carbide tools. Most of our recent laboratory work on this project has been concentrated on diamond-free electrolytic operations. Although details cannot be revealed at this time, two different methods of operation have been developed, both of which show a certain degree of promise. Maintenance of a satisfactory rate of cut, and reduction of edge erosion to satisfactorily low levels have been two of the many difficulties encountered. They require much more investigation before the practicality of the process can be definitely established.

CONCLUSIONS

Electrolytically assisted diamond-wheel grinding of single-point carbide tools appears to be even more promising than in the latter part of 1952 when the first report was published. Laboratory results have been confirmed by controlled comparisons in which actual carbide tools have been ground. In every test, considerable amount of diamond bort was saved (about 75%), and rates of cut were equal to or slightly less than obtained with vitrified-bonded diamond wheels used conventionally. Tool performance was as satisfactory as that of tools ground conventionally. A toxic condition may arise from gas generation by electrolysis, but this apparently can be overcome by proper exhaust placed near the grinding contact.

In spite of these promising results, we feel that caution should be exercised in replacing conventional diamond-wheel grinding of single-point carbide tools by *any* of the newer methods at the present time. Some of the reasons are:

1. Most of the newer methods are in their infancy, when developments are rapid and changes sometimes revolutionary. A premature capital expenditure may preclude adoption of a substantial improvement at a more propitious date.

(Continued on p. 166)

Table II – Results of Tests by Carbide Tool Manufacturer

Test Data	Method of Grinding	
	Conventional	Electrolytic Assistance
Concentration of diamond in wheel	50	100
Linear wheel wear per 100 tools	0.0043 in.	0.0008 in.
Over-all grinding time per 100 tools	130 min.	140 min.

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Grinding Carbide Tools

(Continued from p. 164)

2. With electrolytic (electrochemical) machining methods, more attention needs to be given to over-all costs and cutting rates compared with conventional diamond-wheel grinding.

3. It cannot be assumed that every type and composition of metal-bonded diamond wheel used with electrolytic assistance, nor every power supply, will perform in the manner described. Neither can it be assumed that the results obtained with this method for sharpening single-point tools will be similar in fixed-feed grinding operations.

4. There seems to be a possibility that an electrolytic method can be developed for sharpening single-point carbide tools commercially without the use of any diamond whatsoever. If this ultimate goal is reached, the machine, and particularly the power supply required, would probably be quite different from that for electrolytically assisted diamond-wheel grinding.

Nevertheless, it seems desirable to continue the development of alternate machining methods employing less diamond (or none at all) as actively as possible, and research and development programs are being pursued in several directions in the Norton Laboratories.

Manufacture of Cemented Carbides*

THE AUTHOR traces the development of techniques of producing cemented carbides in order to evaluate the impact of new technological facilities on the art. To this end, he first reviews the history of electric furnaces from the time of the Moissan arc, in which the first refractory carbides were made, to the high-frequency induction vacuum furnaces used in the most modern plants. The history includes the development of the carbon and the graphite-tube furnaces, heated by passing heavy current at low voltage through their length. Only carbon

(Continued on p. 168)

*Digest of "Changes in the Techniques of Manufacturing Cemented Carbide Alloys", by Carl Ballhausen, *Stahl und Eisen*, Vol. 71, Oct. 11, 1951, p. 1090.

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Manufacture of Cemented Carbides

(Continued from p. 166)

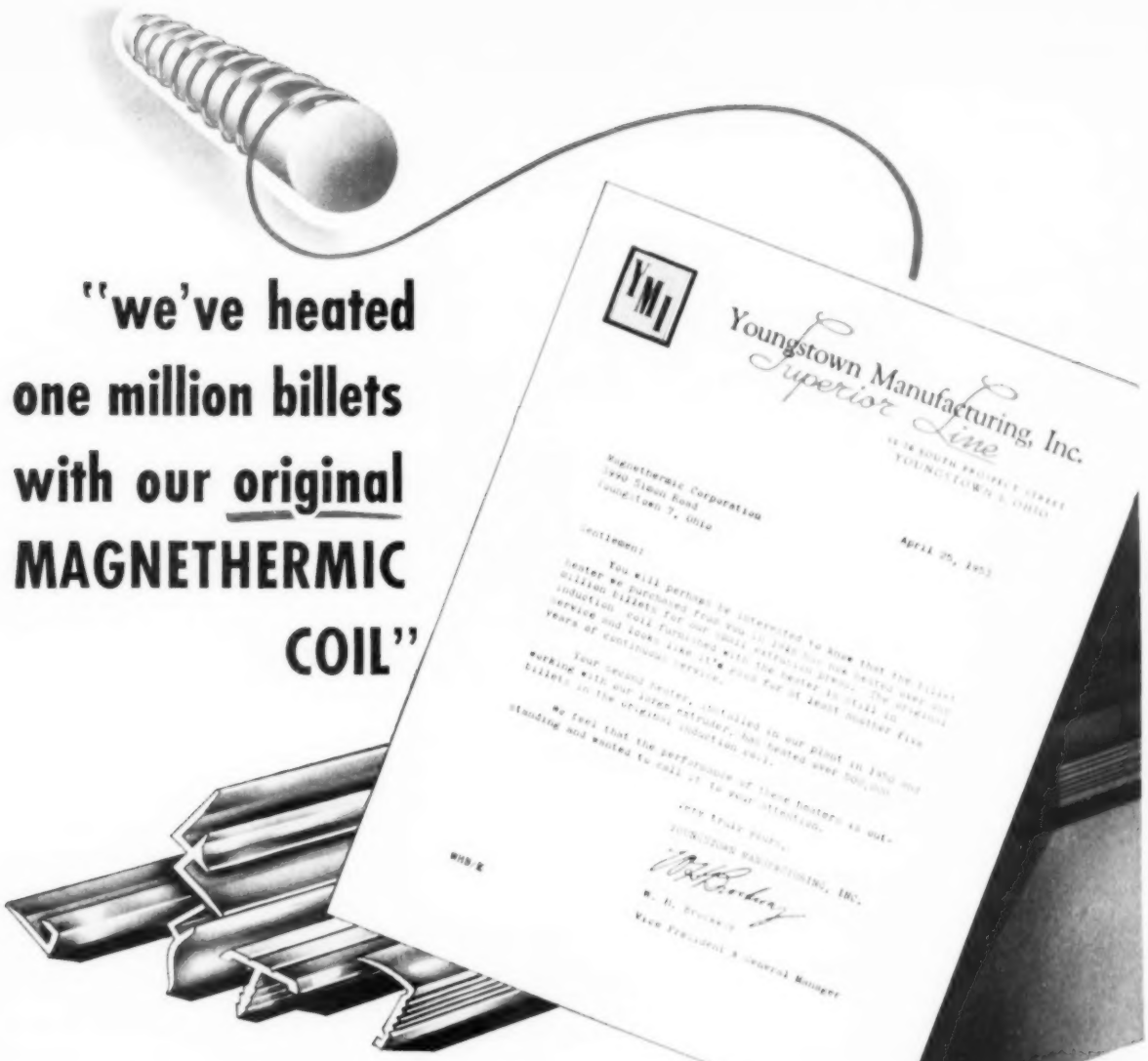
had the necessary high resistance to use direct current at the voltages available for appreciable power; it was not until the advent of alternating current that large enough currents could be made available, by the use of transformers, at low enough voltages to use other materials, such as the iridium used for a tube furnace by Tammann and the tungsten or molybdenum tubes which were developed later.

Early efforts were directed toward making tungsten carbides by foundry techniques, and very fast melting was necessary to prevent contamination by the atmosphere or from the crucible. When powder-metallurgy techniques became available in the 1920's, not only for carbides but also for metallic tungsten and molybdenum, furnaces heated by tubes, rods or wires of these two metals and others came into extensive use. But to prevent decarburization of carbides, a return to the carbon-tube furnace took place in the early 30's.

The hydrogen atmosphere, still used for straight tungsten carbide grades, was replaced by vacuum when titanium carbide additions were developed for steel-cutting tool tips. The author built the first inductively heated carbon furnace in 1930, and used it with both hydrogen and vacuum for carburizing and sintering. The current was produced by motor-generator at frequencies of 2000 to 10,000 cycles. Higher frequencies have not been extensively used in this field, even with the advent of electronic converters, and resistance heated or medium frequency heated graphite-tube furnaces are still used. Molybdenum-wound furnaces are also used.

The author then reviews the development of techniques of reducing tungsten oxides or other materials. The early gas-heated hydrogen furnaces were replaced by nichrome-wound electric furnaces, which are still used. The process moved from the batch-type to the continuous furnaces, in which boats containing the oxide are fed in at one end at frequent intervals, and hydrogen is introduced at the other end. Also used

(Continued on p. 170)



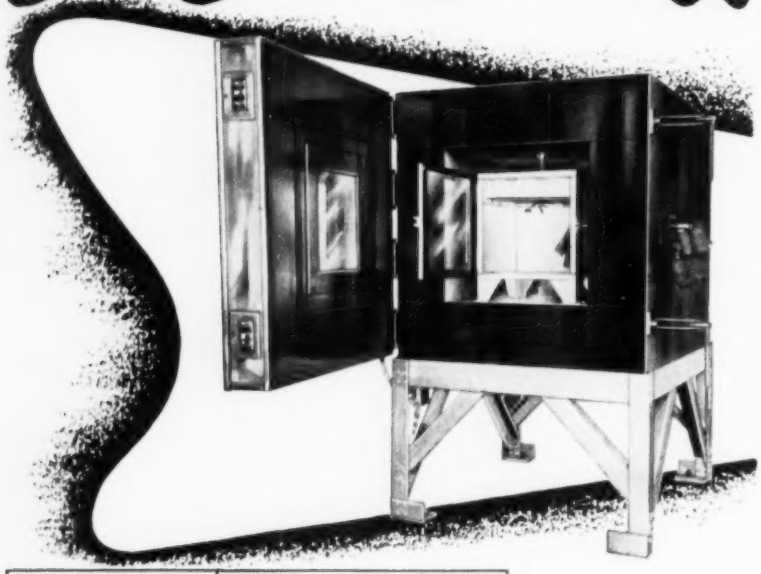
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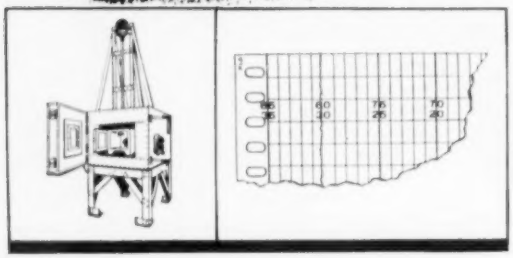
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Manufacture of Cemented Carbides

(Continued from p. 168)

are tube furnaces in which the tube is itself the heating element. Tungsten for use in carbides is made in some plants in a tilted tube furnace in which the tube is rotated about its own axis. Boats are not needed, and the rotating-tube furnace has many of the advantages of continuous production. Occasionally the oxide is mixed initially with sufficient carbon both to reduce it and to carburize it. Hydrogen is then not needed, but control of the carbon content is more difficult.

The technique of carburizing is reviewed. Tungsten metal is first ball-milled with gas black, sugar carbon or graphite, then compressed to small compacts which are placed in carbon boats; these are passed slowly through a hydrogen-containing carbon-tube furnace at 1400 to 1600° C. (2550 to 2900° F.), depending on the particle size desired. The same procedure is used for titanium carbide, except that the starting material is the oxide rather than the metal, and the temperature is as high as 2250° C. (4080° F.). Mixed carbides are prepared by the same process, the titanium starting as oxide, and the tungsten as carbide, metal or oxide. Temperatures are intermediate.

A carburizing apparatus devised by the author consists of a pair of slowly rotating graphite rolls, between which passes a mixture of tungsten and titanium oxides and carbon; current is passed through the material across the roll gap, and reduction and carburization take place continuously, each particle being in the gap for only about a minute. A subsequent heat treatment in an induction furnace is used to homogenize the carbide and regulate its composition. The whole operation is more efficient because heated space is not wasted by the oxide-carbon briquets.

Auxiliary equipment is discussed. Early mixing, crushing, milling, and sieving were done on machines developed in other industries. They were unnecessarily large, and the materials used in their construction led to contamination of the carbides. Eventually, the following machines

(Continued on p. 172)

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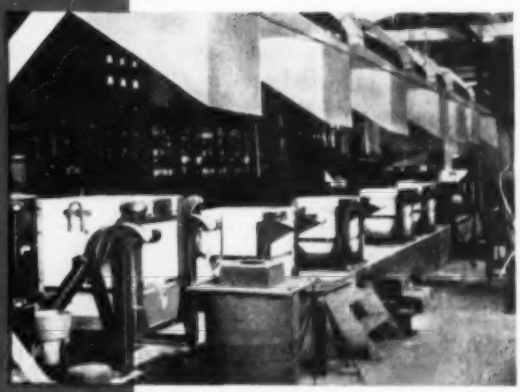
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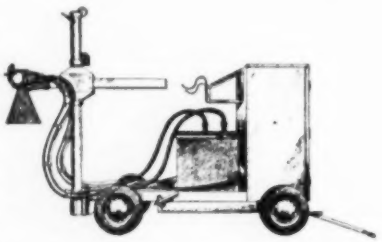


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Manufacture of Cemented Carbides

(Continued from p. 170)

were developed: drum mixers with paddles rotating in the same direction as the drum; crushers having carbide-lined jaws; hammer mills or eddy mills with carbide wearing parts; ball mills, some mounted on springs and made to oscillate; of carbide or stainless steel with carbide balls; and finally small specialized vibrating sieves.

Various media have been tried for the lengthy ball-milling of carbides with binder metals. Problems of oxidation, difficulties in drying, and the evolution of corrosive or toxic products during drying have led to the development of synthetic saturated hydrocarbons with low and definite boiling points. These can be re-used if the drying process is made efficient. The barrels of ball mills can be heated electrically or by water-bath and connected to a vacuum pump, the milling medium being recovered in a condenser or in the pump fluid itself. Some of the milling media cause pumping difficulties. Large driers equipped with agitator, condenser, and rotary pumps are also used with success. A reduction step following drying is sometimes required, particularly if the binder metal has become partly oxidized.

The compression step for carbides is generally designed on the basis of a double sintering operation. Large compacts are pressed, presintered, and cut into the required shapes before final sintering. A powder lubricant is generally used which can be removed in the presintering furnace; for example, 1% camphor in ether solution is common. To prevent laminar cracking during ejection, low pressures (4000 to 8000 psi.) are used; in addition, complex dies capable of releasing the compact laterally at the time of ejection are sometimes necessary. Several designs are described.

Presintering, done at 1650 to 2000° F., requires a hydrogen-tube furnace similar to the ones used for reduction. For batch operation, high-frequency vacuum furnaces are occasionally used, but the condensation of evaporated pressing lubricant is a difficult problem.

(Continued on p. 174)

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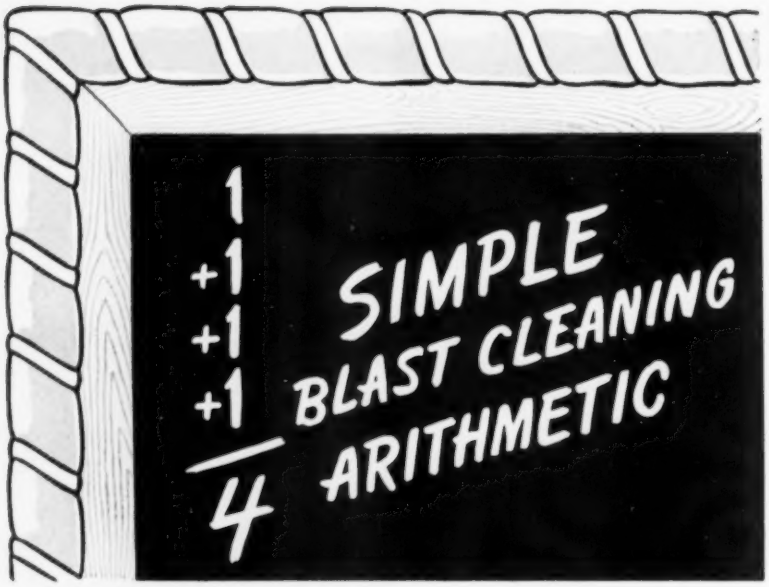


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Manufacture of Cemented Carbides

(Continued from p. 172)

Presintered carbide blocks can be machined, but are brittle. Accordingly, they are usually sectioned by means of abrasive cut-off disks and shaped with profile abrasive wheels. Some operations, like drilling and turning, are done on conventional tools. The cut-off wheels have become specialized. Thin (50 to 70 microns) diamond wheels have replaced rubber-bonded silicon carbide wheels once used exclusively. Disposal of the abraded dust and the prevention of wheel loading are problems; the author discusses several tricks of the trade. The shrinkage that takes place during final sintering must of course be taken into account during the cutting.

While the procedure just described is customary for shapes sold in big lots, special shapes are pressed to final form in segmented, carbide-lined dies mounted in subassemblies. Steel dies are still made up and used occasionally; these consist of a frame within which a variety of component pieces can be fitted to form any of several die shapes. Individually pressed and sintered articles can be finished by grinding and polishing with diamond or boron carbide. The author discusses various designs of presses and dies for individually forming various shapes required in metal-cutting tools.

The technique of extruding shapes of carbide, to be sintered into long thin pieces, such as twist drills, is discussed briefly.

Hot pressing, generally in a graphite die, is used for special shapes of cemented carbides. A shaped hole in the die is filled with the powder, and pressed under 1500 to 2200 psi, while the die is heated to 2370 to 2900° F., depending on the material, for 3 to 15 min. The shape and surface perfection of the piece are equivalent to those obtained in die castings. The disadvantage of the method is that the graphite die cannot be used more than once. Heating is done in one of several ways: The die may be placed inside a carbon resistance furnace; current may be passed directly through the die or through the punches; or the die assembly may be heated by high fre-

(Continued on p. 178)

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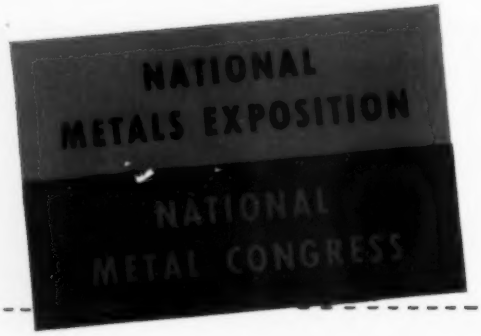
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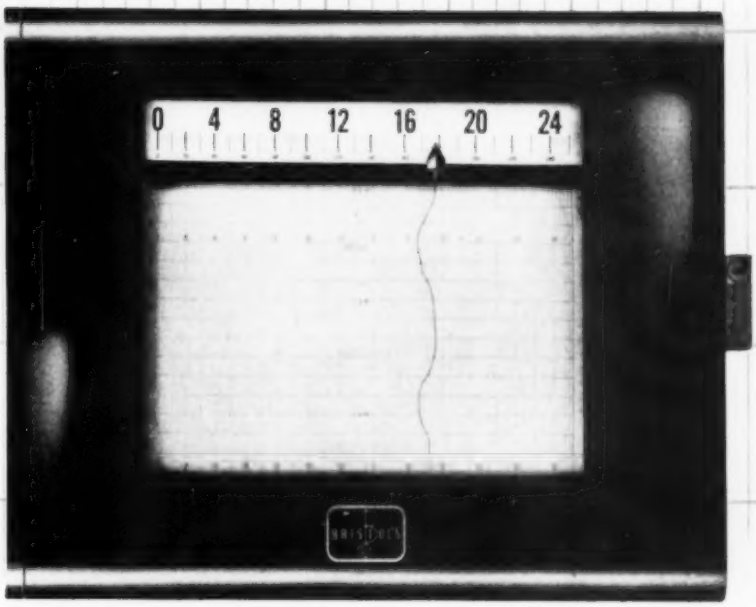
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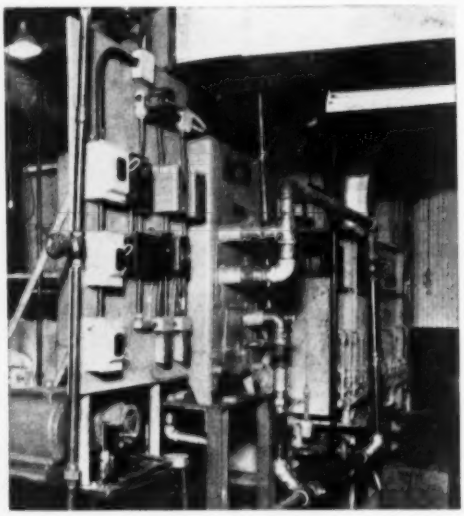
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Manufacture of Cemented Carbides

(Continued from p. 174)

quency induction. Hot pressing is the preferred technique for carbides for use in rock drilling, and is required for some of the tungsten-free hard metal compositions.

Final sintering of pressed and presintered briquets is usually done in carbon-tube resistance furnaces. The compacts are placed in carbon boats, and are packed in granulated carbon or aluminum oxide. The boats are pushed through the furnace at a speed of 1 in. in 5 to 10 min.; temperatures (from 2550 to 2900° F.) are measured by optical pyrometer through end windows. Hydrogen at 17.6 cu.ft. per hr. is fed into the tube at the exit end. Sintered compacts are sand-blasted to free them of adhering carbon powder.

Titanium-containing compositions become decarburized by hydrogen in a carbon-tube furnace, and therefore must be sintered in vacuum. Vacuum-sintering was first used for these compositions in 1930, and, from the beginning, high-frequency induction was the means of heating. Vacuums of the order of 0.1 to 0.5 mm. of mercury (cold) are sufficient, provided the apparatus is so gas-tight that this pressure can be maintained without pumping for periods of an hour or so. Heating is done by induction with a 400-volt maximum tension across the furnace coil, and a frequency of 2000 to 10,000 cycles. Electronic generators are not used because there is no advantage in using frequencies higher than 10,000 with graphite susceptors. The compacts are packed together with carbon separators in the graphite crucible which serves also as susceptor; they are heated to the necessary temperature for 1 to 2 hr., and cooled in the furnace. Cooling may be accelerated by letting hydrogen in at a pressure of about 50 mm. One advantage of vacuum-sintering as compared with the use of a hydrogen atmosphere is that graphite parts last much longer.

Sintering in molybdenum-wound aluminum oxide tube furnaces is not used extensively in Germany. Good control of temperature is obtained through the use of molybdenum-tungsten thermocouples. The com-

(Continued on p. 180)

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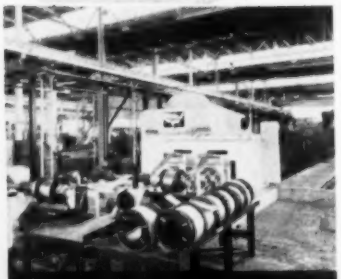
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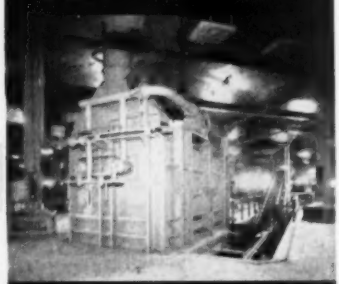
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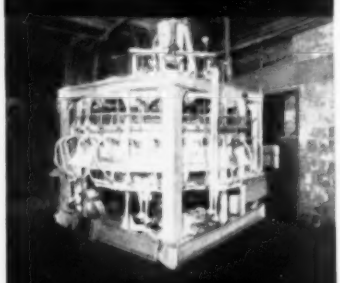
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Manufacture of Cemented Carbides

(Continued from p. 178)

pacts must be packed in granulated carbon and therefore need sandblasting after sintering, whereas with vacuum-sintering this step is avoided.

Preparation of cemented carbides ends after the final sintering, but elaborate testing usually follows before the product is shipped. For instance, distortion is checked; all cemented carbides shrink considerably during sintering, and distortions can be introduced by uneven shrinkage. This may arise from faulty powder handling, faulty pressing, leading to density differences within the compact, or even from restraints to shrinkage imposed on compacts during sintering by the way they are packed in the crucible or boat. Very good conformity to dimensional specifications is particularly important in metal-cutting grades of carbides, since mass production of machined parts depends on their uniformity and reliability. M. BASCH

Free Iron in Brass*

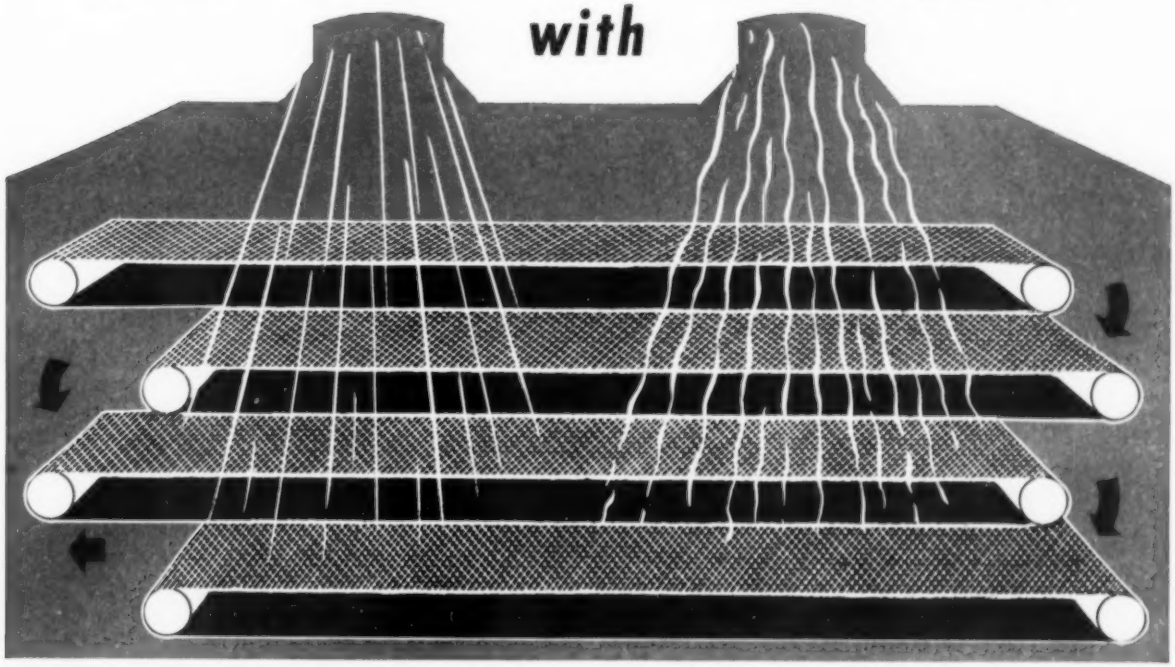
THIS CONTRIBUTION concerns "drag marks" that appeared in polished sections of brass ingot which, on microscopic examination, were found to be due to an aggregation of inclusions of free iron. The drag marks had the appearance of rectangles about 1 in. square, the lines being from $\frac{1}{8}$ to $\frac{1}{16}$ in. thick. Origin of these iron particles was considered to be associated with the scrap used in the melt; although it had been magnetized, not all of this contaminant had been removed (a very common thing when the iron is fine and oily).

Further demagnetization did no good. A low-melting-point flux was stirred into the melt to wet the iron particles and enable them to come to the surface and be removed in the skimming. A few minutes should elapse after the addition of the flux to permit the iron to agglomerate. Metal cast after this treatment was free of "drag marks" as well as of the free iron. H. J. ROAST

* From "Free Iron in Brass Ingot", an item appearing under Foundry Briefs in *Metal Industry*, November 1952, p. 364.

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Steels for Cold Extrusion*

Although most production experience of the cold extrusion of steel is still largely confined to low-carbon materials of deep-drawing quality, some results of development investigations using higher carbon and alloy steels are available.

Reductions in the range of 85 to 90% in the forward extrusion of steels having up to 0.47% C and 0.60% Mn have been reported by H. D. Feldmann. Attainment of great reductions without fracture is one of the important characteristics of the cold extrusion process. The high working pressures, which present serious problems to the tool designer, are favorable metallurgically. The mechanical properties obtainable in cold extruded steel are very good; a fine-grained, aluminum-killed steel of 0.10% C, which has received reduction of 75%, may have a strength of 110,000 psi., 15% elongation and 50% reduction in area.

The initial heat treatments which have been applied have been aimed at producing a soft condition in order to limit extrusion pressures. These include spheroidizing, annealing, normalizing and also normalizing followed by quenching and annealing. For a given composition, a microstructure containing fairly coarse spheroidizing carbide particles may be expected to give the lowest extrusion pressures. Steels with carbon contents up to 1.2%, having such a structure, have been cold extruded on a laboratory scale. However, spheroidization is often a costly treatment and a structure containing coarse carbides will not develop the best combination of strength and toughness in the finished product.

For the higher carbon steel components which are intended to go into service in the "as-extruded" condition, the initial microstructure selected will be a compromise between what is desirable as to extrusion

(Continued on p. 184)

*Digest of "Metallurgical Requirements of Steels for Cold Extrusion", by D. V. Wilson, a paper presented at the Special Conference on Cold Extrusion of Steel, organized by the Sheet and Strip Metal Users' Technical Association, London, May 12 and 13, 1953, and published in *Sheet Metal Industries*, Vol. 30, June 1953, p. 513.

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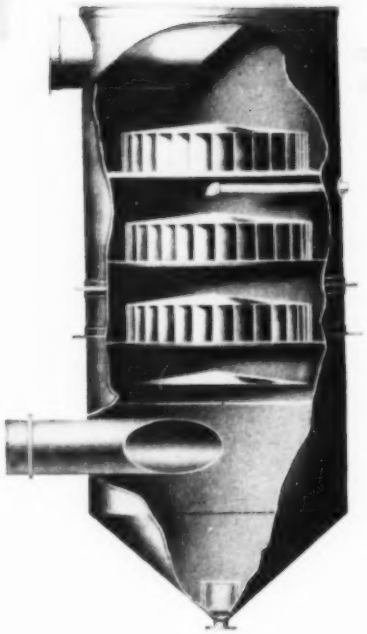
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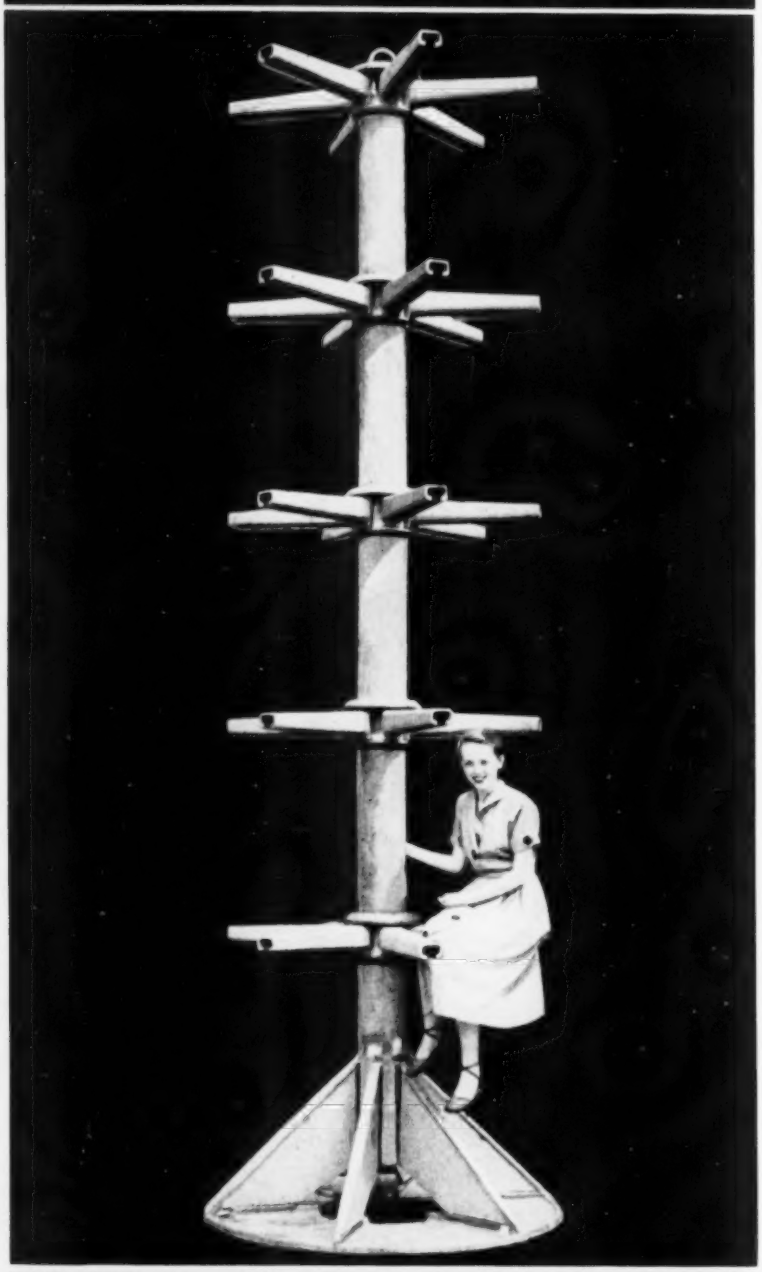
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Steels for Cold Extrusion

(Continued from p. 182)

pressures and the final properties.

For a given carbide particle size the best properties will be developed if the carbide is distributed evenly throughout the structure. In particular, "banded" structures and local concentrations of carbide will be detrimental. The ideal material for cold extrusion would be completely free from nonmetallic inclusions, and from directionality in the microstructure. It is also recommended that the steel should have a homogeneous structure with fine spheroidized carbide particles and grain size not larger than A.S.T.M. No. 5. Normalizing has been used successfully in Germany; Lloyd and Kopecki report that Heintz Manufacturing Co. (U.S.A.) soak the steel above the critical range and then water quench to preserve an even distribution of carbides. After quenching, the steel was softened by annealing. The annealing temperatures were generally just below Ac_3; for example, 1545° F. for low-carbon steels. This would produce rapid softening but preserve a fine grain size. After annealing for 2 hr., the steel was furnace cooled at 80° F. per hr. to room temperature.

If intermediate softening is required during a sequence of extrusion operations, this generally is a subcritical anneal. The time and temperature, which should be selected to give a fine-grained recrystallized structure, will vary to some extent with composition and the degree of previous cold working.

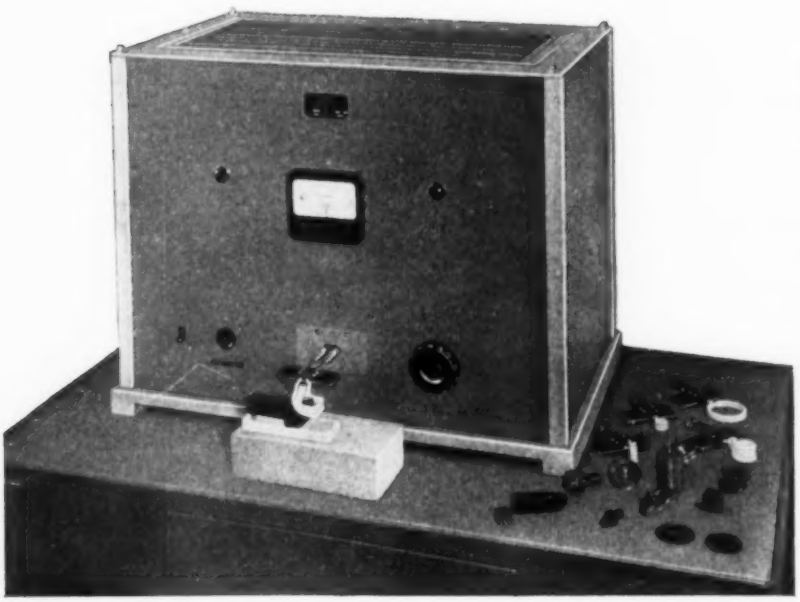
SURFACE QUALITY REQUIREMENTS

The surface quality of the blanks used in cold extrusion is often important and must be considered in relation to details of the specific operation. In backward extrusion of a blank of smaller diameter than some part of the die (under such conditions the first deformation is essentially an upsetting operation), small surface defects may open up and cause defects on the external surface of the pressing. So far as external surface quality is concerned, forward extrusion, in which a reduction in external diameter occurs, is generally

(Continued on p. 186)

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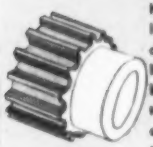


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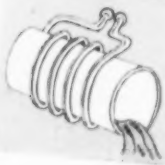
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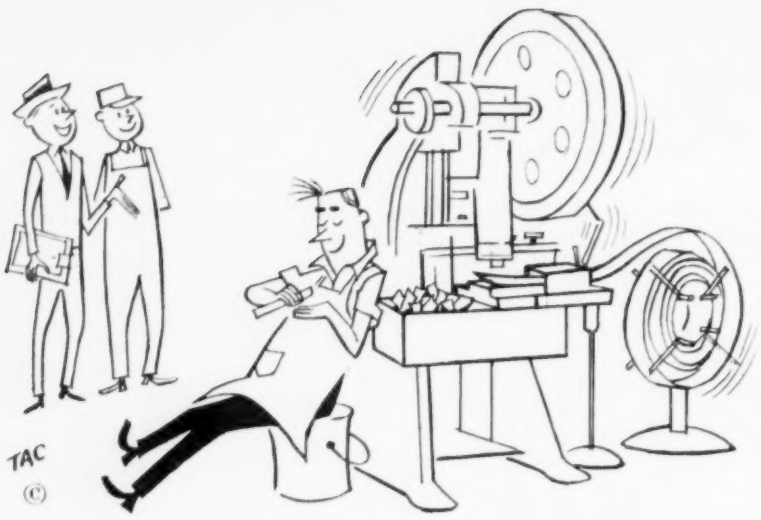
1/8"	steel rod 1" length in approx.	1 second
1/4"	" " " " " "	3 seconds
1/2"	" " " " " "	15 seconds
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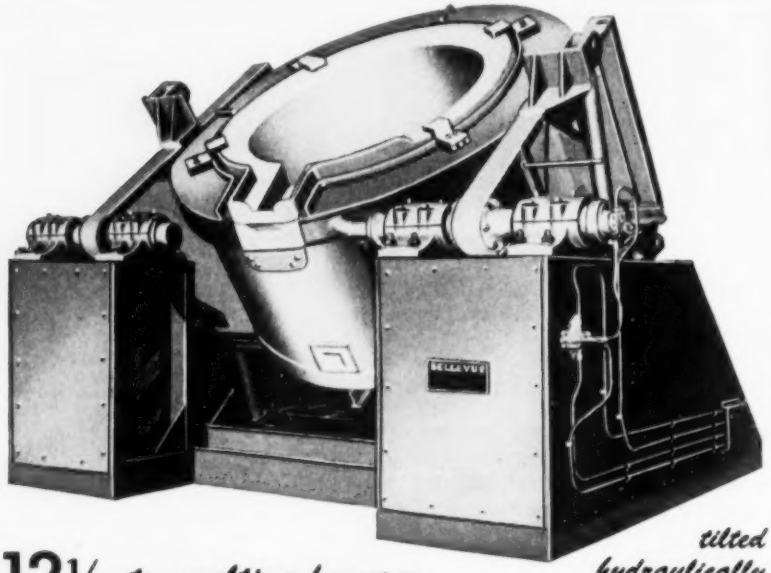


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A lever handle control valve is mounted on side of furnace . . . metal is heated by means of burners mounted below the pot, firing tangentially to the internal lining. This gives a uniform heat distribution and avoids flame impingement on the pot, contributing to longer pot life. Unit may be built for gas, oil, or gas-oil combination firing . . . Venting out the hot gases takes place between the pot and the refractory ring at the top of the furnace. The internal lining of the furnace is made from first quality fire brick, backed up with sufficient insulation, to minimize heat losses. The large capacity allows a single pour to fill a complete mold, thus eliminating subsequent pours . . . The large diameter of the pot opening allows charging of large pieces of metal . . . Pot size, 76" diameter by 37" deep . . . *send for complete information.*

Bellevue INDUSTRIAL FURNACE COMPANY
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Steels for Cold Extrusion

(Continued from p. 184)

least critical, because metal flow is then such as to iron out surface irregularities. Under conditions of satisfactory lubrication quite exceptional surface quality can be obtained in the finished component.

So far as extrusion pressures and the toughness of the finished component are concerned, strain age hardening is an undesirable characteristic of steels. However, if a sufficient proportion of an element which has a strong chemical affinity for carbon (such as titanium or vanadium) is added to a steel, the carbon is "fixed" and the usual strain-aging phenomena may be largely eliminated. The true "nonaging" or stabilized steels deserve consideration, particularly where deformations are high and service requirements are stringent.

INFLUENCE OF STRESS-RELIEVING

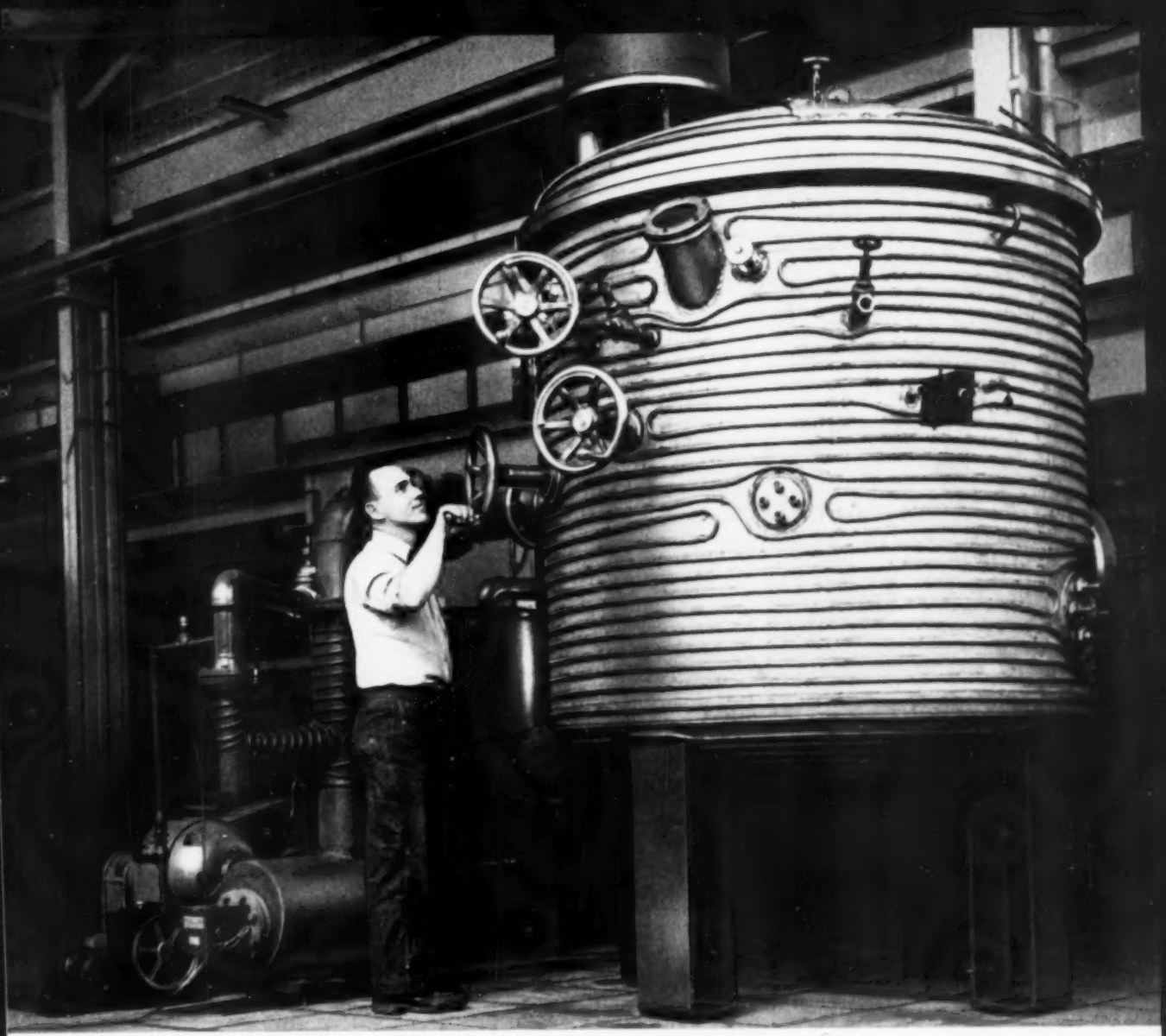
At times, relief of internal stress and a useful improvement in toughness may be achieved by a stress-relieving anneal after extrusion. Although stress-relieving at a sufficiently high temperature will improve the ductility properties of an extruded steel component, this treatment must be applied with discrimination when maximum strength is to be maintained.

In Germany, deep-drawing quality aluminum-bearing steels have been widely used for extrusions which are to be highly stressed in service. Fine-grained steels of this type retain a useful degree of toughness in the cold worked condition. A typical analysis of a steel for present German specifications for cold extrusions is: 0.10% C (max.), 0.18% Si, 0.3% Mn, and 0.04% for S and for P.

More recently development work has been carried out on steels of more ordinary quality. In view of the excellent results obtained on these extrusions, as well as the great consistency of mechanical properties shown by cold worked components, it has been suggested that some relaxation of the standards of material quality may be permissible in cold extrusions.

For applications of extruded or

(Continued on p. 188)



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The high vacuum metallurgical furnace illustrated above is typical of the large units *CVC* is designing and manufacturing.

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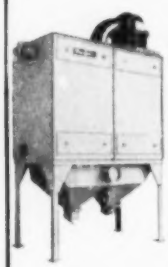
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Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment

Pangborn
BLAST CLEANS CHEAPER
with the right equipment for every job

Steels for Cold Extrusion

(Continued from p. 186)

drawn components requiring the maximum reliability in transverse properties, the Germans have used very clean steels. Often, only the central half or third of a fine-grained aluminum-killed ingot was used. For highest quality requirements, sulphur and phosphorus contents were generally less than 0.03%, manganese less than 0.4%, and silicon less than 0.1%, with residual aluminum greater than 0.02%. Ingot surfaces were scarfed and, after hot rolling, longitudinal and transverse impact tests were often made.

Apart from the effects of insoluble or segregated impurities, which reduce transverse ductility even in the annealed condition, cold working superimposes its own directional influences on the metal. "Fibering" of the microstructures, particularly when a hard constituent is present, can impart good properties in the direction of extension at the expense of transverse ductility.

J. PARINA, JR.

British Views of Shell Molding*

IN A ROUNDUP of the history and development of shell molding both in Britain and in the United States, J. G. Pearce summarized progress of the technique in America. He mentioned one company† which, at the time he investigated, was producing 40,000 exhaust valves in cast steel per 8-hr. shift by shell molding, and between 4000 and 5000 crankshafts for a new 6-cylinder engine (the crankshafts being made of nodular iron).

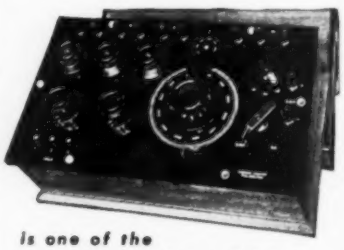
Finished machined weight of the crankshaft was 85 lb., two being cast in one shell mold and the total weight of metal poured 200 lb. It was estimated that 15% by weight of an engine unit was shell molded.

(Continued on p. 190)

*Digest of "Discussion on Shell Molding", by J. G. Pearce and W. B. Parkes in Research Report No. 347, *Journal of Research and Development*, British Cast Iron Research Association, December 1952.

†In all probability he was referring to the Ford Motor Co.

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TEMPERATURE MEASUREMENT



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. . . a general purpose potentiometer with a number of notable refinements, suiting it particularly to thermocouple work. Distinctive features include:

- Three ranges —0 to 16 millivolts, 0 to 160 millivolts and 0 to 1.6 volts.
- Three reading dials—effective scale length of approximately 175 feet for each range.
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This standard laboratory potentiometer is also well suited for meter calibration, for checking portable potentiometers, and for other critical measurements of D.C. potentials requiring exceptionally high accuracy.

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- For null or deflection measurements

Described in Bulletin 320

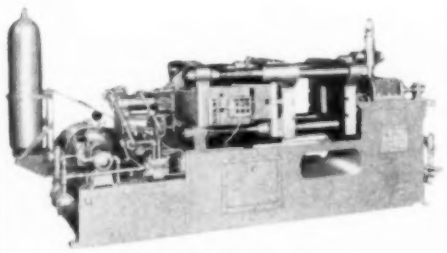
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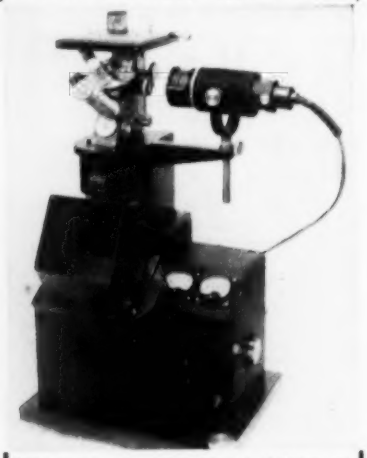
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British Views of Shell Molding

(Continued from p. 188)

Dr. Pearce reported the process was consuming two to three million pounds of resin per year in the United States. One supplier of synthetic resin estimated that if, by 1957, only 5% of the castings output were to be from shell molds then a total of some 80,000,000 lb. of resin would be required annually, or roughly two-thirds of the volume of phenolic resins now used for all molding purposes.

Essential steps in the production of shell molds start with a metal pattern heated to 350 to 500° F. and sprayed with a parting liquid to facilitate subsequent stripping of the shell. A paraffin solution was first used but now one of the silicone emulsions is generally favored. Next a dry mixture of fine-grained sand and 5 to 9% of a powdered synthetic resin is sprinkled over the pattern. After standing for 5 to 15 sec., the pattern is reversed and excess sand falls away, leaving a coating of sand-resin on the pattern. Oven baking at 520 to 650° F. for 40 to 100 sec. sets the resin and the shell can then be removed from the pattern. Shells are pinned and clamped together to form complete molds and usually are buried in steel shot for support.

In considering dimensional accuracy, 0.003 in. per in. of length is an average figure, although numerous examples have been reported of a considerably greater degree of precision. For instance, a casting 1 ft. long was made in quantity with a maximum variation of plus or minus 0.01 in. Such measurements would be made on a section of the casting contained entirely within one shell; variations are likely to be greater when measuring across the parting line of the shell.

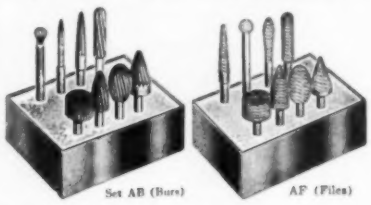
Among early difficulties was sticking of the shell to the pattern, particularly when new. Silicone emulsions have now eased this problem. The pattern is sprayed on the rotary table generally used for continuous production – or in some cases dipped – immediately before it is clamped to the dump box. In some machines, spraying is preceded by brushing, both operations being automatic. In smaller hand-operated setups, spray-

(Continued on p. 192)

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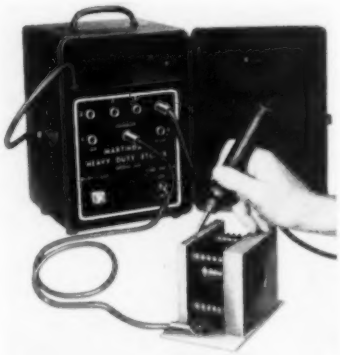
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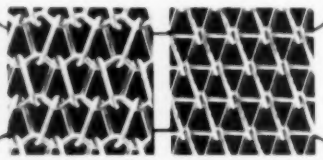
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British Views of Shell Molding

(Continued from p. 190)

ing the pattern once in five or even ten operations has been found adequate. New patterns can be "broken in" by applying several times the normal amount of emulsion, or a thicker emulsion, and heating for several hours.

A wide divergence of opinion is noted about comparative costs of castings, green sand molded versus shell molded. However, it is fair to conclude that the over-all cost of a casting made in a shell mold is appreciably higher, a considerable share of the added cost being charged to pattern expense.

This position might change to an important degree. Thus, a reduction in cost of resin (which frequently amounts to 40% of the cost of producing shells) would have telling effect. Likewise an inexpensive and effective method of securing the two halves of a mold would be beneficial.

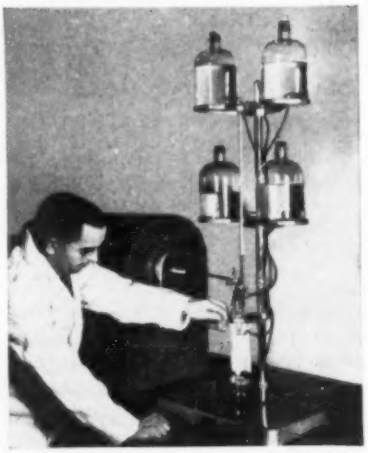
Hollow cores with a wall thickness similar to that of shell molds can be made by the same process, although information on this practice is limited. Its advantages should include savings in sand, elimination of the long-cycle baking oven, better surface finish — often as good as a conventional core coated with blacking — and greater accuracy since the shell is cured in contact with the core box, thus eliminating the likelihood of sagging.

A representative of Rolls-Royce Ltd., outlining his company's experience in making high alloy steel castings (14% Ni, 20% Cr) by shell molding, described shells 12x16 in. in size, each carrying six impressions and requiring only eight ½-in. lifting pins. Shells were held together by half a dozen small G-clamps and there was no tendency noted toward buckling or distortion in pouring. The process proved to be slightly less expensive than green sand molding, even though pattern costs were higher. Castings previously made by the lost-wax process could be produced at half the cost by shell molding, and a dimensional accuracy maintained of 0.005 in. per in. of length in one shell and of 0.007 in. across the joint. A. H. ALLEN

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Said guide "Shaggy" Peters as he spat past the Professor's steaming sox into the embers. "Shooting crows at 200 yards and 'chucks at 400 ain't gotten from books- that's gun pointing, Prof."

The top-hand from the research-mill, aching in every joint, glanced at his three-point buck swinging in the shadow, and rubbed on more liniment. "Manual dexterity and good eyesight is, admittedly, a factor," he replied, "and practice sharpens both. But cognizance *and control* of minutia are the prime criteria of superlative performance. Top scores, particularly predictably *repetitive* scores, come from the elimination, reduction, and *control* of variables in techniques, tools, and materials . . . pass that 'Hudson's Bay' to Tom and me before you kill the bottle." (Gulp.)

Continuing: "Tom, here, is a metallurgist. After wrestling with grain-size control in complex alloys, Tom 'relaxes' by loading his own shells and dynamically balancing his bullets. His pet rifle, capable of only 5-in. groups on the target at 200 yards, with factory ammunition, repeatedly scores under 2-in. groups with his own engineered loading.

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"You, Shag, are a prime example of keen perception of detail. To track game, predict weather, cajole fish onto hooks, you *perceive* and *coordinate* more minutia and phenomena than a research scientist, and *that* doesn't come from books either. I should know! I bought half a library from Abercrombie & Fitch, but I might die of starvation within five miles of camp without your practical guidance." Nudging Tom: "Wake up and put down your nightcap."

Tom, surveying the bottle: "Hogs, both of you, but philosophers at heart. Closing the gap between theory and practice is the obvious approach to understanding. Both can be wide of the mark. The *fact* is, that individual marksmanship played no part in closing down my groups. This was all rest shooting, of course, with the score improvement made back on the loading bench. I enjoy the attainment of accuracy for itself, but would also like to be sure of a crow or a woodchuck, not just scare him after maneuvering cautiously and waiting patiently for a shot. I figure that if I can knock off the small targets, the big ones will come naturally."

Shag spat on his whetstone. "'Twist tobaccy juice is better'n oil for keenin' a skinnin' edge," he remarked. "You talk technical, but I get the drift about little things addin' up to big ones. My gramp who died at 93, ahlwin' his bald spot with four Injun scalps wove into his hoss-tail belt, used to tell me, 'Larn how to savvy the little critters, and you'll ketch on to the big 'uns. Use yore five senses—they'll bring you grub and keep you livin'." You technical birds don't seem to be able to smell nothin' short of a daid polecat."

Tom, moving his sleeping bag, "The heck we don't. That's why we sleep to your windward, you old he-goat."

And the owls, mice, and forest folk ignored those who trespassed against them and carried on under the stars.

* * * *

Tom Franks, V.P. of General Alloys, worked summers in the G.A. foundry, laboratories, and engineering department between studying metallurgy at the University of Illinois (including the first curriculum relating to heat and corrosion resistant alloys, set up at our suggestion by Dr. Stanley Parr, inventor of Illium, the first and most successful platinum replacement). He applies precision thought and function in his hobbies as well as in his work—as many who entrust him with their alloy problems have enthusiastically verified. Two of his hobbies are the construction of glass fishing rods calibrated to a minnow's whisker, and rifle and pistol shooting, loading his own ammunition.

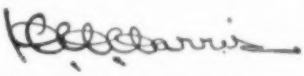
Tom Franks explains his "Gun-Buggery" as follows:
Hand loaded cartridges give higher accuracy than standard factory ammunition. Reasons:

1. Powder charges. Factory ammo charges are volumetrically measured. "Gun-bugs" weigh them to a tenth of a grain. Rod-shaped powder particles stack like kindling in defying accurate volume measurement.
2. Commercial bullet weights, diameter, and concentricity vary. He rejects bullets not meeting 0.0004 diametrical tolerance and varying 0.25 of one per cent in weight. Concentricity is checked by spinning bullets on centers and recording wobble of the projected shadow.
3. Shells of commercial tolerance must interchange in gun chambers. The maximum case must fit easily into the minimum chamber. Therefore, a minimum case in a maximum chamber is a loose fit, causing a variation in breach pressure, in nozzle velocity, and accuracy.
4. A fired cartridge conforms to a gun chamber under the high breach pressures. Therefore, re-used fired cases (many times re-usable) fit accurately, produce most uniform breach pressures, improve accuracy.
5. Commercial practice includes a space left in the chamber throat before rifling, so that a cartridge of maximum dimension (plus or minus a little dirt) can be seated without being forced into the rifling by the bolt. This leaves a "gap" the bullet must jump, with possibility of tilt, and with impact to cause barrel vibration affecting accuracy.
6. Each individual gun performs best with a given powder charge and bullet weight combination. Tom has tried over 20 combinations for the optimum result. The relatively few combinations available in factory ammunition can result in top performance with a given gun by coincidence only.
7. Hand loading permits employment of latest technical refinements in new powders, bullets, lubricating wads, etc., as well as full flexibility in weight of charge and bullet. "Engineered like a good G. A. Alloy job." Incidentally, it, too, saves money.

* * * *

The "high scores" of men and organizations (for example, the *unequalled* life performance *records* and *low-cost-per-heat-hour records* of General Alloys' products in high temperature and corrosion resistant service) are a direct reflection of *training* and the *capacity* of the individual or organization to *perceive, assimilate, appreciate*, and *coordinate* complex, specialized technical detail.

That General Alloys is headed and staffed by men with the capacity, *intellectually*, and *technically*, to objectively *evaluate*, and effectively *employ* the most advanced technology in our field of complex metallurgy, engineering and casting practice, is attested by the *superior performance of G. A. products over the greatest variety of applications and the longest period of time.* That G. A. has engaged in far greater casting research and development effort than contemporaries, including trade associations, is a logical part of our ceaseless quest for process and product improvement. "Those who have less to offer—offer for less."



An "aditorial" by the President of General Alloys Company, Boston, Mass.

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Corrosion of Structural Materials in Water*

This report should serve as an extremely useful reference for the selection of materials to be used in the construction of equipment to handle water in the temperature range from 500 to 600° F. As more experience is gained in this range of operation, the value of the data presented will increase.

The results of extensive corrosion tests on stainless steels and numerous other materials in water at temperatures from about 70 to 650° F. have been presented in detail. Most of the data were obtained for water at 500° F. and containing about 30 cc. of oxygen per liter at the start of the test period. Several tests were also conducted at 600° F. in water which was first degassed by several minutes of boiling. Tests were conducted in autoclaves in which the water was relatively static. Some of the materials were tested in each of the following environments:

1. Six samples in individual baskets were supported in an autoclave that was connected to an oxygen bottle to maintain an oxygen partial pressure between 510 and 730 psi. Concentrations of dissolved oxygen were calculated to be between 2300 and 3300 cc. per l. of water.

2. Oxygen partial pressure in the autoclave was maintained between 335 and 510 psi., the calculated oxygen concentration in water being between 1500 and 2300 cc. per l.

3. Sufficient oxygen was added to an autoclave to give a concentration of about 240 cc. per l. of water at the start of the tests, with no further additions of oxygen.

4. The test was started with a hydrogen content of about 70 cc. per l. of water but without additions to maintain this concentration.

5. Specimens loaded in tension to less than 10,000 psi. were exposed to water flowing at 30 ft. per min. The oxygen concentration was maintained between 3 and 5 cc. per l. by necessary additions as determined from chemical analyses.

Results of a few isolated tests with high initial hydrogen potentials obtained by various additives (sodium dichromate, hydrogenated water, and with combinations of these) are also reported.

By far the most extensive tests were conducted on Type 347 stainless steel, the material used in the construction of the autoclaves and circulating systems. Various methods of joining this alloy to others were investigated and contact corrosion tests were made to determine the suitability of other materials when used in contact with Type 347 stainless steel.

Most of the specimens were in the as-machined condition, after degreasing with trichlorethylene or acetone. Some of the samples were passivated with aqueous nitric acid solutions.

Included in the results are the test conditions, the description of the specimens after exposure, the change in weight of the specimens as removed after testing, and the over-all rating of the sample as either good, poor, or doubtful. During several tests up to 7000 hr. in duration, the specimens were examined periodically and the results of these intermediate inspections are in-

(Continued on p. 196)

*Digest of "Water Corrosion of Structural Materials", by C. R. Breden, S. Greenberg, R. M. Robinson, A. H. Roebuck, V. F. Saitta, and C. C. Scott, Report No. ANL 4519, Argonne National Laboratory, July 1951.



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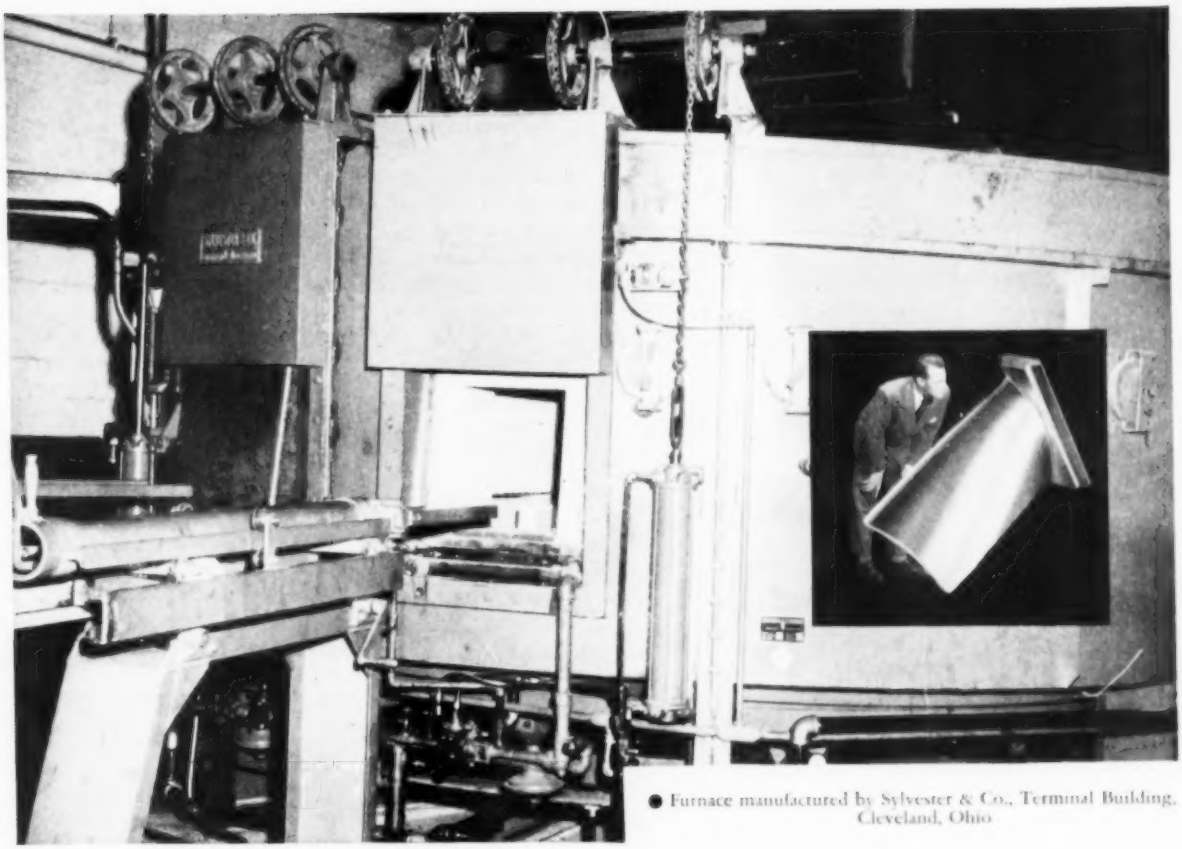
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Corrosion of Structural Materials in Water

(Continued from p. 194)

cluded. A typical set of the observations made during such a test is given in Table I.

In Table II on p. 198 the results for stainless steels and other common structural alloys tested in static, oxygenated water (30 cc. per l. at the start) at 500° F. have been summarized by placing the alloy in one of four categories of evaluation.

The materials rated as satisfactory formed tightly adherent, relatively uniform films, and exhibited no severe galvanic action when in contact with Type 347 stainless steel autoclaves. The coatings that were formed on the alloys ranged from light yellow, blue, or violet tarnishes to dark brown or black scales. Generally, these films were lustrous in appearance and in a few cases the samples did not change from their original appearance before the test was made.

A material was classified as unsatisfactory if the corrosion products were loose or if pitting had occurred. These loose corrosion products were powdery, black or rust-colored, and could be easily brushed from the surface. Very often a more tightly adhering film occurred beneath the loose powder.

The major reasons for classifying the behavior of a material as doubtful were: *(a)* Conflicting results were obtained on several samples; *(b)* some loose corrosion products had formed after extended periods of test, although they were not observed during shorter tests; *(c)* results for some specimens seemed to depend on surface treatment; *(d)* large weight changes indicated more corrosion than was apparent from visual inspection.

Some interesting results obtained from the less numerous tests at the other conditions were:

1. The austenitic chromium-nickel stainless steels exhibited satisfactory resistance to corrosion under all test conditions.

2. As-welded joints on Types 304 and 316 stainless steels were as satisfactory in oxygenated water at 600° F. as Type 347 joints.

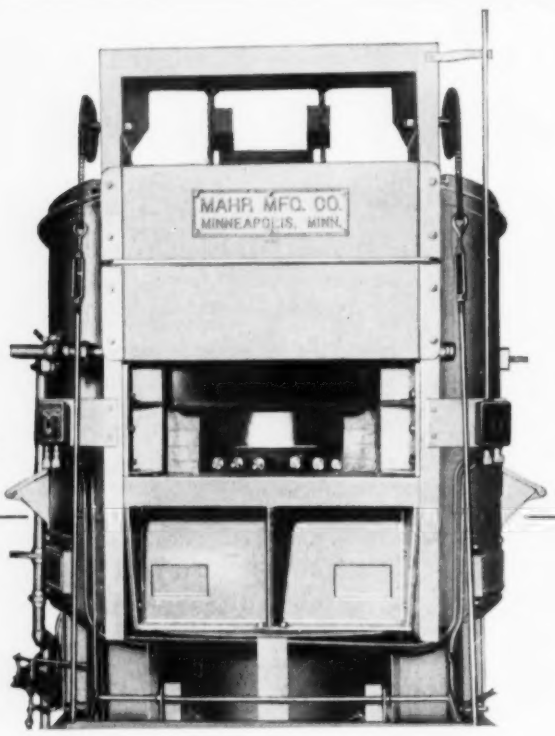
(Continued on p. 198)

Table I — Typical Data for Long-Time Corrosion Tests of Passivated Type 347 Stainless*

Time Increments, Hr.	Corrosion Rate†	Appearance and Comments
324	+0.19	Sample covered with dark yellow, blue, and violet tarnish.
860	+0.048	Autoclave dry at end of period. Faintly lustrous yellow-brown coating.
768	−0.041	No change.
715	−0.059	Beginning with this period autoclave inverted. Tarnish slightly darker.
741	+0.055	No change.
718	0.00	No change.
784	−0.014	No change. Autoclave dry at end of period.
710	+0.029	No change.
694	+0.090	No change.
738	+0.057	Dull blue-brown tarnish.
712	0.000	No change.
7762		

*Passivated in 20% HNO_3 at 160° F. for ½ hr. Test conducted in water at 500° F. and containing 30 cc. oxygen per l. water.

†In mg. per sq.cm. per month.



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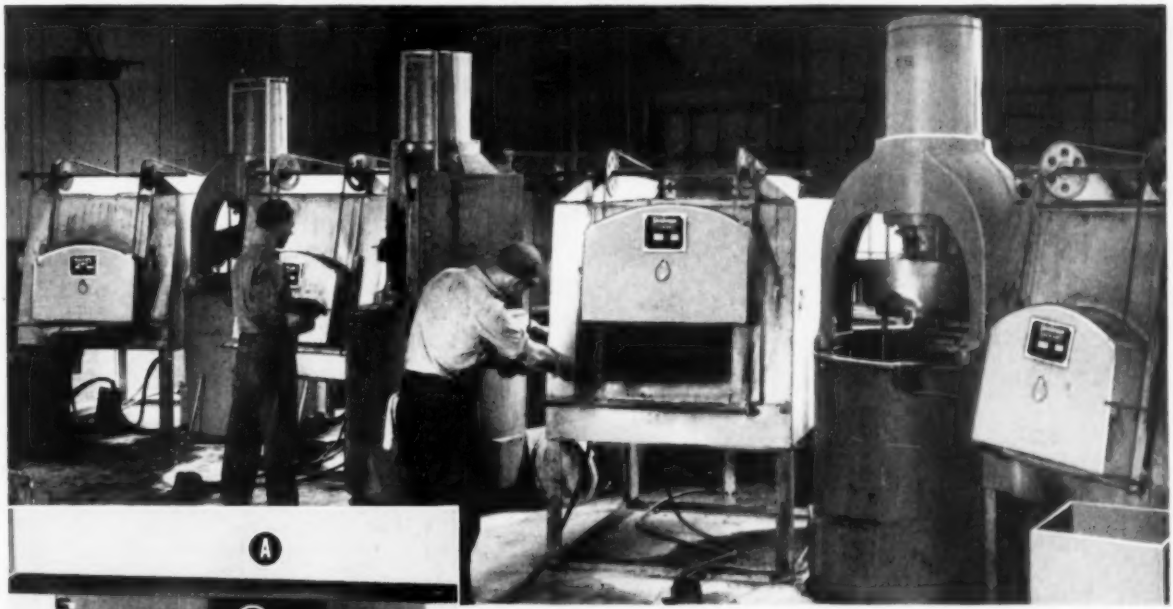
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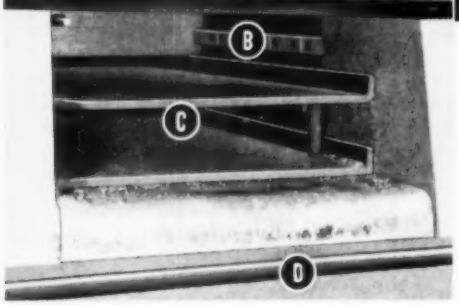
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AT STYBERG ENGINEERING CO., Racine, Wisc.





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In the fabrication and heat treatment of clutch rings at Styberg Engineering, parallel tolerances on the sidewalls of rings 18" in dia. had to be maintained to within .0005. In addition, high physical properties with good impact and wear characteristics had to be obtained. Clutch rings varying in dia. from 9" to 18" O.D. with a wall thickness of .126 + .000—.004" tolerances are heat treated in five Sunbeam Stewart Electrically heated ovens. The larger rings of 18" dia. must pass through a gage slot .135" wide by 18" deep with walls parallel within .0005.

Due to extreme critical tolerances, automatic equipment could not handle the work satisfactorily. Therefore, a battery of five electrically heated Sunbeam Stewart double-shelf, atmosphere-controlled, oven-type furnaces provided the most practical heating equipment. One endothermic gas generator supplies the atmosphere to the furnaces. A non-oxidizing, non-decarburizing atmosphere allows full hardness to be obtained throughout the cross-section of the ring.

These Sunbeam Stewart furnaces are designed to provide high heat input with low wall losses. This is ideally suited for production requirements as extremely rapid recovery of the furnace to the control temperature occurs upon loading cold work. Rapid return to temperature reduces waiting time, allowing a larger, steadier production. Because of its wide operating range, this Sunbeam Stewart unit is ideal for general purpose heat treating including hardening of carbon and alloy steels, normalizing, annealing, and pre-heating high speed steels, etc.

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A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM industrial furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM engineer will be glad to call and discuss your heat treating problems with you.

Corrosion of Structural Materials in Water

(Continued from p. 196)

3. Initial experiments indicated bad over-all corrosion of Type 347 specimens which had been heated in the sensitizing range after welding.

4. Results obtained both from autoclaves and circulated water indicated no problem of crevice corrosion with Type 347.

5. Martensitic stainless steels were inferior to austenitic stainless

(Continued on p. 200)

Table II — Autoclave Tests of Structural Materials in Oxygenated Water at 500° F.

Satisfactory After 4 Months	Satisfactory After 2 Months
Stainless Types 304, 316, and 347	Stainless Types 304L, 318, 302B, 303, 305, TS347A and 446
347,* welded to 347†	304, welded to 304L with 304L rod
347,* welded to 304†	Fahralloy, as-cast
347,* welded to 316†	C-1, as-cast
304,* welded to 304‡	U.S.S. Stainless W, welded to 347†
316,* welded to 316*	Armco 17-4PH, Malcomized
Armco 17-7, age hardened	Armco 17-7PH, Malcomized
Armco 17-4, age hardened	Armco GT-45
U.S.S. Stainless W, age hardened	Carpenter 20
Durimet 20	Multimet
Stellite 3, 6 and 12	Bachrach Alloy
Elgiloy	Haynes Alloy 25
	Stellite 1, 4, 19, 21 and 98M2
	Stellite, graphitic
	Ampco 15, 18 and 18-23
	Cupro-Nickel (70-30)
	Chlorimet 2
	Durco D-10
	Illium G
	Inconel X
	Monel
	Nicrobrazed stainless steel (302)
	Iridium-nickel alloy SR-10271§
	Rhodium
	Tantalum-tungsten alloy
	Titanium Ti-75A§

Not Satisfactory
Stainless Types 316L, 405, 410, 420, 431, 440C, 440F, and 501
309, Malcomized
316, Malcomized
347, Malcomized
302, Scottsonized
347, Scottsonized
A.S.M.E. SA-212, Grade B
Hi-tensile
Cromoco toolsteel
Discalloy 24
FCC-66 toolsteel
Ni-Hard and Ni-Resist
Nusite
Ontario toolsteel
Stellite 93
Stellite Star J
Vascoloy-Ramet 166
Ampco 8
Ampcoloy A-3
Ampcoloy 45
Bronze, leaded
Copper
Alnico VI
Hastelloy A, B, C and D
"K" Monel and "S" Monel
Nickel-molybdenum alloy (96 Ni, 4 Mo)
Hevimet
Silver
Silver bearing alloy (85 Ag, 10 Mo, 5 Cu)

Not Evaluated, Data Doubtful
Stainless Types 302 and 321
TS347-A, welded to same†
304, Malcomized
A-Nickel
Ceco 100 Metal
Chlorimet
Illium
Inconel
Fansteel
Tantalum
347, chromium plated
S.A.E. 52100, chromium plated

*As welded and quench-annealed from 1950° F.; water at 600° F. with 240 cc. O_2 per l. added at start of each period.

†Welded with 347 rod.
‡Welded with 304 rod.
*Welded with 316 rod.
§Tests made at 600° F.

Standard or Special Design

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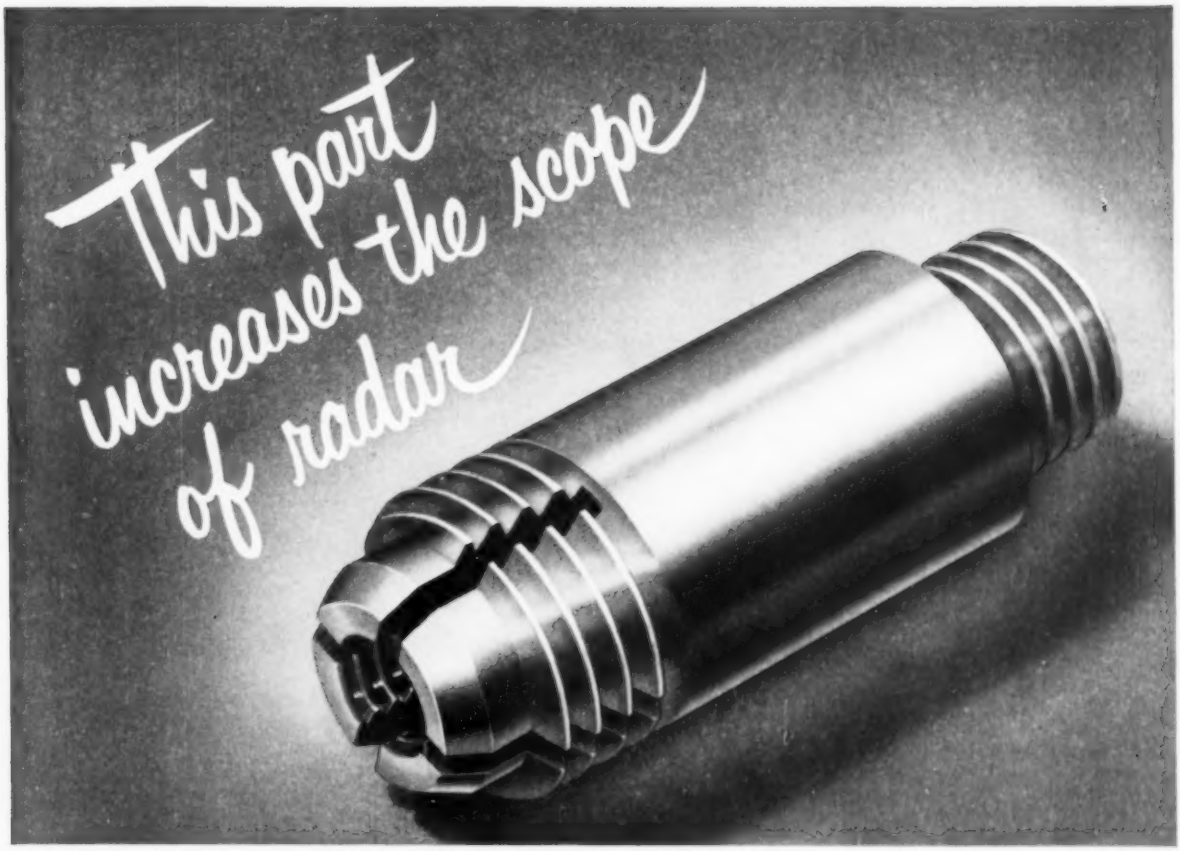
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Corrosion of Structural Materials in Water

(Starts on p. 194)

alloys in static, oxygenated systems, but appeared to be satisfactory in degassed water or in flow systems containing small amounts of oxygen (3 to 5 cc. per l. of water). Alkaline additives improved resistance to high-temperature water corrosion, but sodium dichromate was ineffective for these martensitic materials.

6. Corrosion behavior of carbon steels is improved by degassification of water or by the addition of hydrogen.

7. Bronzes and copper-nickel alloys are more resistant to corrosion in degassed water than in oxygenated water.

In the ratings of the materials, as presented in the report, the main consideration was that a minimum amount of corrosion products was lost to the system. Thus, although a material was rated in many instances as unsatisfactory, the actual amount of corrosion was not so great that the material could not be used for certain kinds of service.

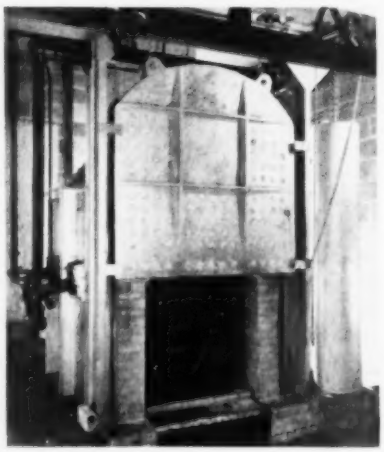
The data would be of much more immediate usefulness had the authors obtained a more quantitative comparison of the corrosion resistance of the materials in the various environments. The "corrosion rates" as reported do not indicate the severity of the attack, since unknown amounts of corrosion products remained on the specimens at the time of the final weighings. This fact was recognized by the authors as indicated by the following statement: "Corrosion rates are thus not a criterion of the performance unless the corrosion product is adherent."

It should be pointed out that even if an apparently adherent scale remains on a specimen, it is possible that substantial amounts of corrosion products may still have been lost to the medium. Such losses may be concealed by the weight gained as the specimens form compounds, whatever their nature, with the corroding agent or agents. Therefore, the actual corrosion rate of a specimen which gave a weight gain is not determined and the rate for a specimen which showed both scale formation and weight loss is greater than indicated by the weight loss.

S. C. Datsko

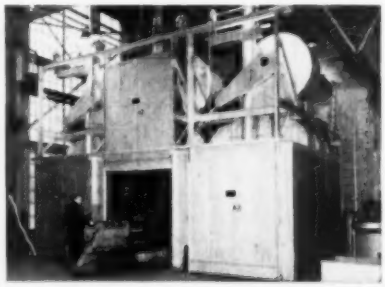
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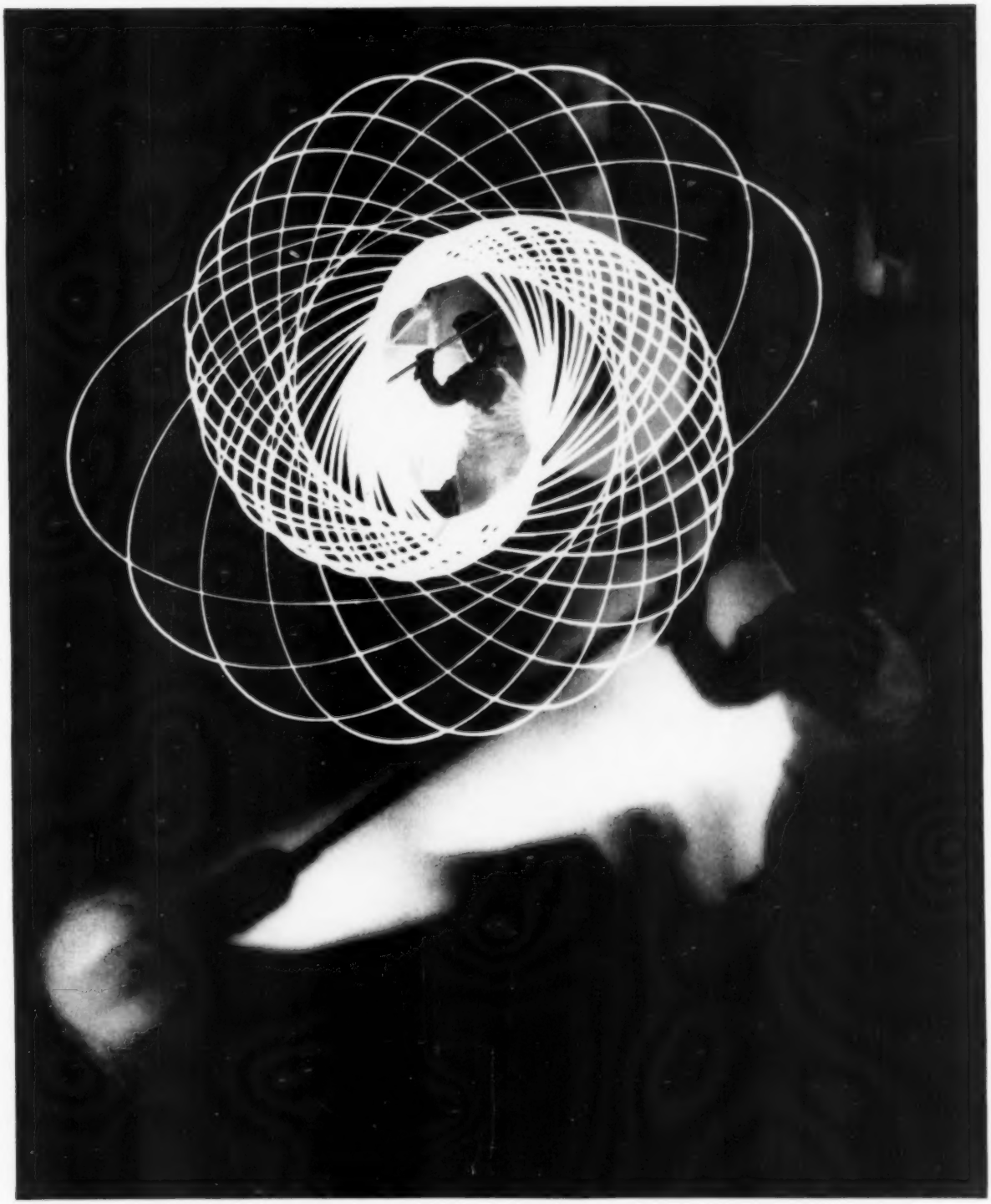


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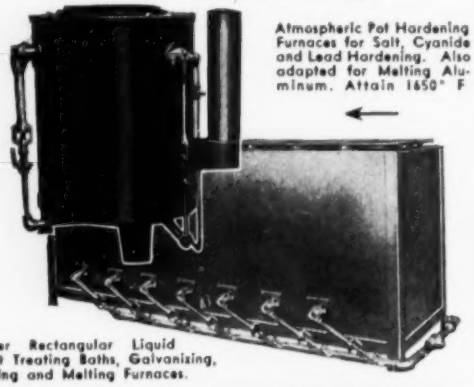
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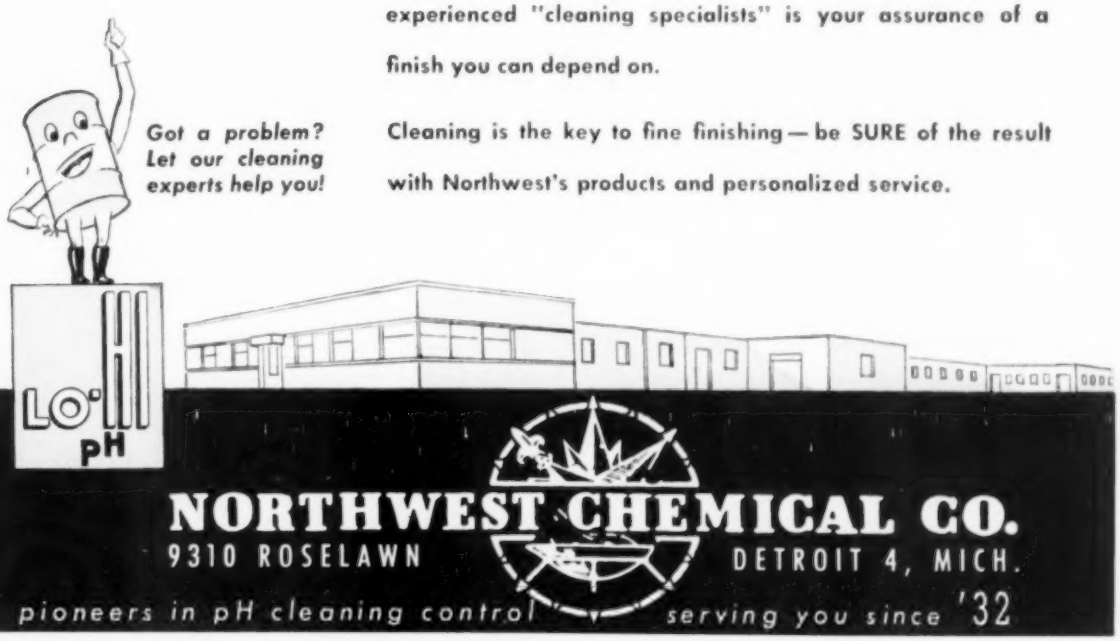


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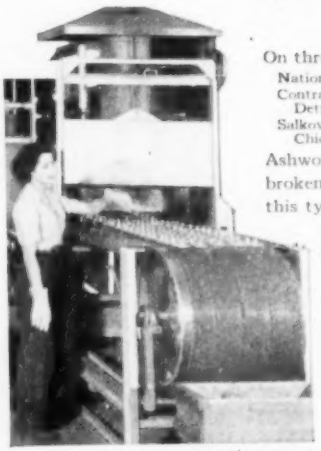


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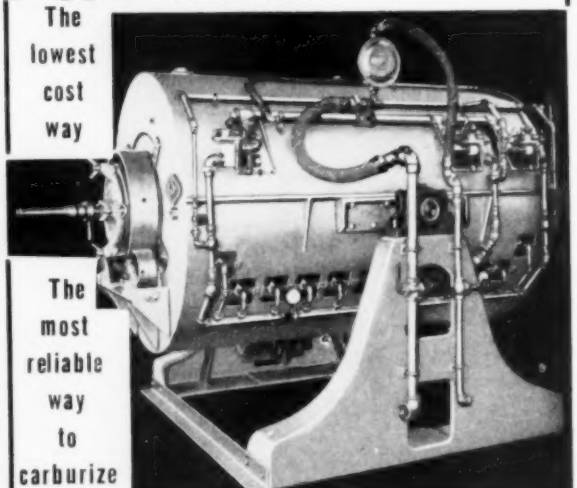
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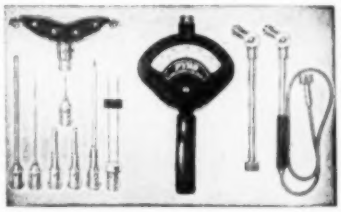
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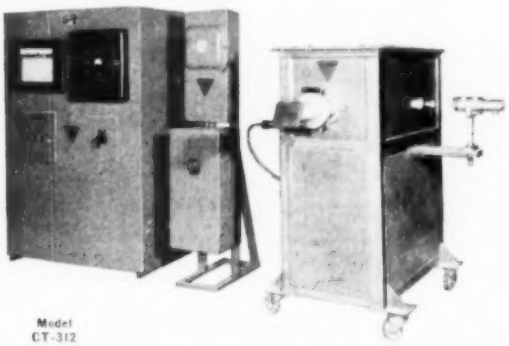
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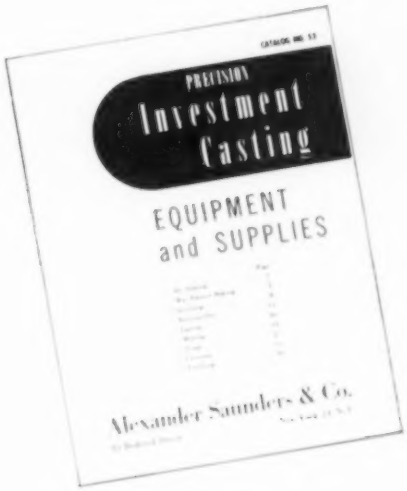
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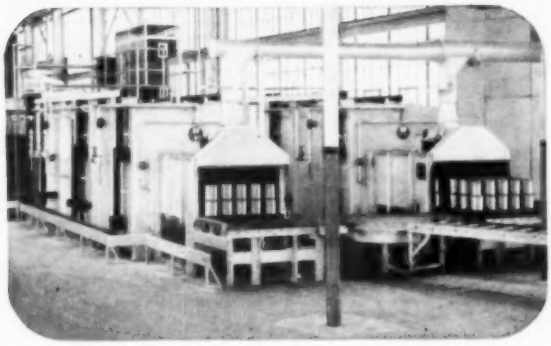
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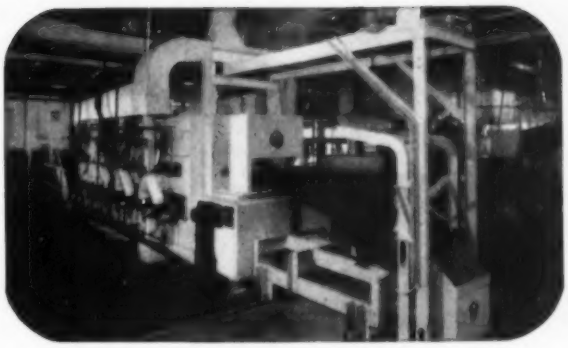
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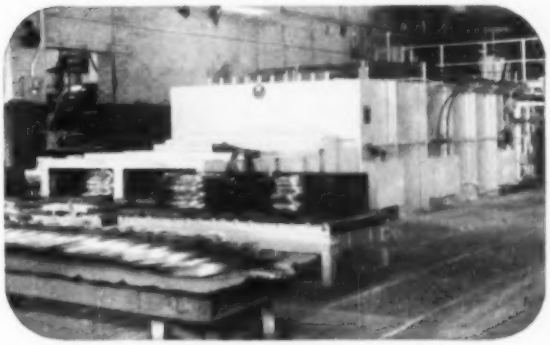
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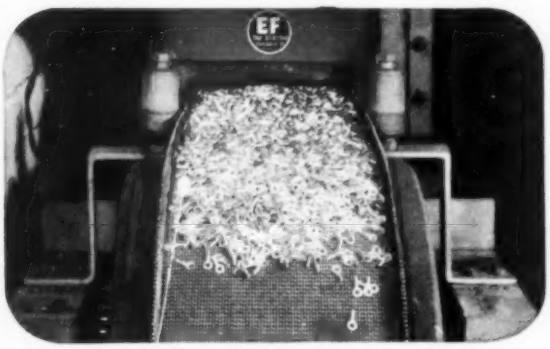
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